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TABLE OF CONTENTS

PRINCIPAL ARTICLES

North America

Bengtson, N. A. Notes on the Physiography of Honduras. (2 maps, 6 photographs) 403–413

Ford, W. C. Early Maps of Carolina. (2 maps) 264–273

Haight, F. J. Nontidal Currents in Southeastern Alaska. (1 map) . . . 642–646

Lee, W. T. An Ice Cave in New Mexico. (3 photographs) 55–59

Matthes, G. H. Oblique Aerial Surveying in Canada. (3 maps, 1 diagram, 2 photographs) 568–582

Platt, R. R. A Note on Political Sovereignty and Administration in the Caribbean. (5 maps) 623–637

Sykes, Godfrey. The Delta and Estuary of the Colorado River. (1 insert map, 6 text maps, 10 photographs) 232–255

Wilson, Ella M. The Aroostook Valley: A Study in Potatoes. (1 map, 5 photographs) 196–205

South America

Hanson, Earl. Out-of-the-World Villages of Atacama. (9 photographs) . 365–377

Jefferson, Mark. Actual Temperatures of South America. (1 map, 27 diagrams) 443–466

Jefferson, Mark. Pictures from Southern Brazil. (1 map, 33 photographs) . 521–547

Marbut, C. F., and C. B. Manifold. The Soils of the Amazon Basin in Relation to Agricultural Possibilities. (2 maps, 8 photographs) 414–442

Murphy, R. C. Oceanic and Climatic Phenomena Along the West Coast of South America During 1925. (2 maps, 2 diagrams, 12 photographs) 26–54

Platt, R. R. Railroad Progress in Colombia. (1 map) 82–97

Shaw, E. W., and J. L. Darnell, Jr. A Frontier Region in Brazil, Southwestern Maranhão. (1 insert map, 1 text map, 12 photographs) . . 177–195

Europe

Vinelli, Marcello. Water Conservation in Sardinia. (1 map, 2 photographs) 395–402

Africa

Boak, A. E. R. Irrigation and Population in the Faiyûm, the Garden of Egypt. (2 maps, 5 photographs) 353–364

Gautier, E. F. The Ahaggar: Heart of the Sahara. (1 map, 7 photographs) 378–394

Renner, G. T., Jr. A Famine Zone in Africa: The Sudan. (3 maps, 6 diagrams) 583–596

Shantz, H. L. The Problem of Tropical Africa: A Review of Recent Books 597–613

Asia

Chu, Co-Ching. Climatic Pulsations During Historic Time in China . . 274–282

Coulter, Wesley. A Dot Map of the Distribution of Population in Japan. (1 insert map) 283–284

Crawford, O. G. S. The Birthplace of Civilization. (1 map) 73–81
Hall, R. B. Quelpart Island and Its People. (2 maps, 7 photographs) . . 60–72
Yetts, W. P. Links Between Ancient China and the West. (1 map) . . 614–622

AUSTRALASIA AND OCEANIA

Clapp, F. G. In the Northwest of the Australian Desert. (1 insert map, 2 diagrams, 13 photographs) 206–231
Taylor, Griffith. The Frontiers of Settlement in Australia. (6 maps, 8 photographs) 1–25

POLAR REGIONS

Hobbs, W. H. The University of Michigan Greenland Expedition of 1926–1927. (1 map, 2 photographs) 256–263
Koch, Lauge. Ice Cap and Sea Ice in North Greenland. (2 maps) . . . 98–107

OCEANS

Hardy, F. H. An Abrupt Change of Depth in the Sulu Sea. (1 map, 1 plan) 296–299

WORLD AS A WHOLE

Dunlop, W. R. Queensland and Jamaica: A Comparative Study in Geographical Economics. (2 maps, 3 diagrams, 5 photographs) 548–567
Gregg, E. S. Ocean Trade Routes. (2 maps) 291–295
Hoskins, H. L. The First Steam Voyage to India 108–116
Jefferson, Mark. A New Map of World Rainfall. (3 maps) 285–290
Popenoe, Paul. The Distribution of the Date Palm 117–121

GENERAL

Bowie, William. Long Lines of Triangulation 638–641
Bowman, Isaiah. The Analysis of Land Forms: Walther Penck on the Topographic Cycle 122–132
Bowman, Isaiah. The Scientific Study of Settlement 647–653
Schureman, Paul. Tides in Wells. (1 diagram) 479–483
Trewartha, Glenn T. Recent Thought on the Problem of White Acclimatization in the Wet Tropics 467–478

DEPARTMENTS

American Geographical Society 133–134, 300–308, 484–485, 654–655
Geographical Record . . . . . 135–156 (2 maps), 309–333 (2 maps), 486–503 (5 maps, 1 block diagram), 656–675 (5 maps)
Geographical Reviews . . . 157–176 (1 map, 1 diagram), 334–350, 504–520, 676–696
Correspondence 350–352

Separate Illustrations

[Map of] Route Traverse in Southern Maranhão. Scale, 1:1,500,000 . Pl. I, opp. p. 194
[Map of] Part of Western Australia. Scale, 1:3,750,000 . . . . Pl. II, opp. p. 230
[Map of] The Delta of the Colorado River. Scale, 1:600,000 . . Pl. III, opp. p. 254
[Map of] Japan: Distribution of Population (1913). Scale, 1:8,000,000 Pl. IV, opp. p. 284

ERRATA

p. 15, line 8 from bottom: *for* Boulin *read* Boulia.
p. 104, line 6 from bottom: *for* Chamberlain *read* Chamberlin.
p. 151, line 14: *for* Lerner *read* Lehner.
p. 152, line 9: *for* LePlae *read* Leplae.
p. 155, line 5: *for* Longevin *read* Langevin.
p. 194, footnote: *for* Pease *read* Pearse.
p. 239, line 6 from bottom: *for* Heintzelmann *read* Heintzelman.
p. 257, line 4: *for* Lester E. Jones *read* E. Lester Jones.

ADDITIONAL ERRATA IN VOLUME XV

p. 319, line 27: *for* T. L. Myres's *read* J. L. Myres's.
p. 270, last line: *for* 6 *n read* 3 *n*.
p. 107, line 19: *for* David *read* Douglas.

ADDITIONAL ERRATUM IN VOLUME XIV

p. 374: the scale on the map should read 0, 5, 10 kilometers and miles instead of 0, 50, 100 kilometers and miles.

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THE
GEOGRAPHICAL REVIEW

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THE FRONTIERS OF SETTLEMENT IN AUSTRALIA

Griffith Taylor
University of Sydney

THE population of Australia, which numbered 5,435,732 in 1921, is spread very unevenly over the 2,974,581 square miles of surface. An area almost as large as the United States has a total population considerably less than that of New York City. The white settlement of Australia started at Sydney in 1788, and it is a matter of considerable geographical interest to see how it has spread through the continent in the course of one hundred and thirty-seven years. Unfortunately our census districts have varied greatly during the last few decades so that it is almost impossible to obtain accurate population-variation charts. However, there are official maps showing the chief grades of population density for each decade, and we can learn much from a consideration of the three last censuses.

Let us take the grade of one person per four square miles (see Fig. 1). Comparing its boundary for 1911 with that for 1901 we find that in Queensland it runs much nearer the coast, but that half a dozen "outliers" mark settlement in the interior. In New South Wales and South Australia the line is the same as in 1901 save for slight increases in the wheat belt in South Australia. In Western Australia a considerable expansion has taken place into the Murchison and Menzies gold fields.

The 1921 census almost everywhere shows no advance on the position of 1901. In Queensland the Barcaldine district has advanced, but elsewhere there would seem to be retreat. In New South Wales a slight retreat to the coast is apparent. In South Australia there is

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little change. In Western Australia there is an advance in the district northeast of Perth.

There has therefore been little addition to the population of the sparsely settled regions, "sparselands" we may call them, in the past twenty years in spite of a growth of one and a half millions in

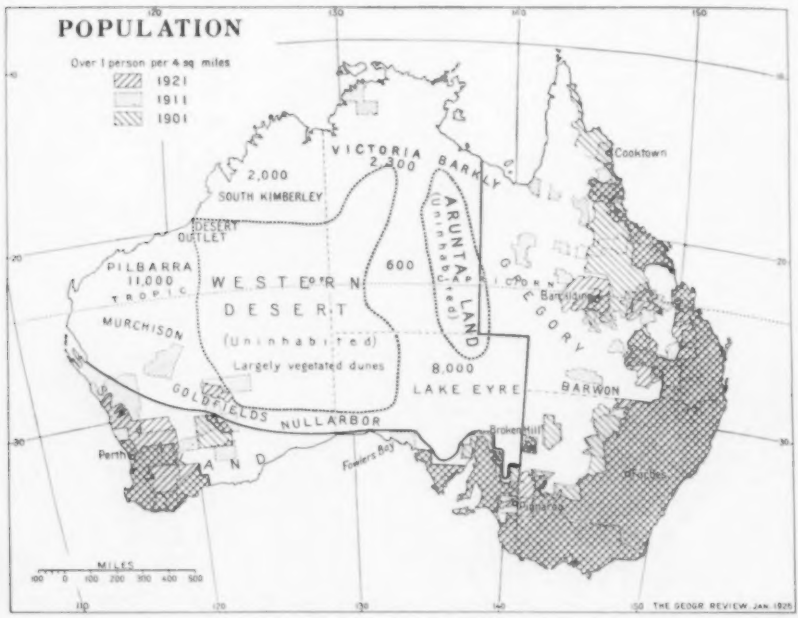

FIG. 1—The distribution of population in Australia at the last three censuses. The dotted lines inclose areas without white population (Western Desert and Arunta Desert). The area north and west of the solid line forming 54 per cent of the total contains little more than ½ of 1 per cent of the population. The districts on the "frontiers of settlement" are named, and the approximate population is given in figures. Scale of map 1 : 44,000,000.

the total population of Australia. Official figures show the following distribution in 1921 (not including a migratory population of 29,765).

Six capital cities	2,338,079	= 43 per cent
Other towns	1,037,468	= 19.5 per cent
Rural population	2,030,422	= 37.5 per cent

If, however, we consider the two millions of rural population we find that only about 100,000 dwell in the sparselands of the eastern states, and only 24,000 in the sparselands of the central and western states (see Fig. 1); in other words about 94 per cent of the total rural population dwells in the reasonably settled margins, and about 6 per cent of the rural population dwells in the sparselands.[1]

[1] See the writer's paper on Australia in Proc. Second Pan-Pacific Sci. Congr., 1925.

The most striking features of the map are the two large areas that contain no white population at all.[2] One of these lies in the east of Northern Territory near the habitat of the well-known Arunta aborigines. We may perhaps call it the Arunta Desert. It has an area of about 60,000 square miles. The larger region, occupying much

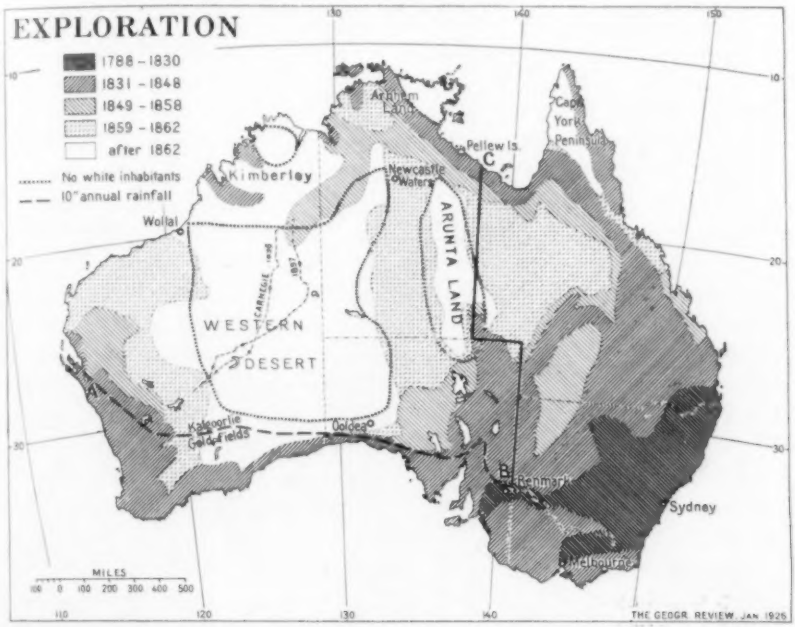

FIG. 2—The progress of Australian exploration. (Limits are based on K. R. Cramp in Bartholomew's "Australasian School Atlas," 1915.) It is seen that most of the utilized lands in Australia were explored before 1862. The line of heavy dashes is the 10-inch isohyet. The area northwest of the line *ABC* contains little more than ⅓ of 1 per cent of the total population (cf. Fig. 1).

of the eastern part of Western Australia but extending into Northern Territory and South Australia, comprises about 440,000 square miles. It constitutes the Western Desert. In these two areas, totaling half a million square miles, there is no white inhabitant and no head of stock, so far as I can learn. One of the main objects of this discussion is to find the reason for this distribution.

EXPLORATION AND PRESENT SETTLEMENT

If the progress of exploration is shown on a map (Fig. 2) a most interesting correlation can be made with the present distribution of population. It is seen that by 1862 Australia was fairly well known

[2] The southwest of Tasmania is also almost uninhabited. But this is owing to the cold, wet, rugged conditions, which are not characteristic of the Australian environment and are quite familiar to dwellers in northern temperate lands. Hence Tasmania is ignored in this study.

except in four regions. These are Arnhem Land and Arunta Land in Northern Territory, West and Central Cape York Peninsula, and finally the huge area of west-central Australia, which we may call the Western Desert or Wilderness. These are precisely the regions with little or no population at present. The only noteworthy exceptions are the Kalgoorlie gold fields and portions of Kimberley. Let us now add the boundaries between the central and eastern states and the 10-inch isohyet in the south. We thus divide Australia into two parts by the line *ABC*. To the southeast lies "inhabited" Australia[3] with 46 per cent of the area; to the northwest lies "uninhabited" Australia with about 54 per cent of the area. In this latter and larger moiety lives about one-third of one per cent of the total population of Australia.

It seems necessary to emphasize these points, because few people realize that almost the whole of "economic Australia" was fairly well known sixty years ago. Most of the explorers who did so much to open up the country in the fifties and sixties were influenced as much by the desire to find new pastoral lands as by the love of exploration *per se*. Within a few years of the first traverse sheep in the south and cattle in the north would push out into the newly discovered lands. The fact that no notable mountain ranges, save perhaps in the Kimberleys, occur anywhere in this region—which indeed is largely a peneplain—means that expansion was not greatly hampered in that respect.

The obstacles to settlement are primarily climatic, but they cannot be explained by reference to any single factor. Temperature, rainfall, humidity, evaporation, topography, geology (including soils, ground waters, and artesian water), and in almost equal degree the resulting natural vegetation have all to be considered in explaining the distribution of settlement. It may surprise the reader that railway communication has been omitted. The writer has studied the effect of a number of railways already built in this huge region, and he has come to the conclusion that railways can do practically nothing to advance population in regions where the environment is not attractive (see the later section on communications).

Acceptance of the dictum that it is the inherent "poverty" of the uninhabited region that has repelled settlement up to the present should not, however, conjure up a picture resembling the moving sand ridges of the Libyan Desert. As in the Sahara, the surface consists chiefly of three types of terrain. Large areas are formed of fixed dunes, and these seem to cover most of the country. There are also extensive regions of sheet waste, sometimes rounded by wind erosion and so forming "gibber plains." There are also rocky expanses relatively free from sand or pebbles. It is not yet possible to show these

[3] Including Kalgoorlie, just on our boundary.

subdivisions on the map. But the central third (from west to east across the Western Desert) appears to contain a large portion of the rocky (or *hamada*) type; the northern and southern thirds are largely of the fixed dune type; while sheet waste covers large areas along the western margin, and the pebbles are common on the southeast margin—as well as in other places of which the writer has no record.

Is There a Desert in Australia?

This brings us to the use of the term desert. The writer recalls the controversy which raged after the publication of J. W. Gregory's "Dead Heart of Australia" in 1906. This title was particularly obnoxious to the members of that large class of "patriots" who believe that nothing but praise is permissible about their native land. Gregory is often referred to today as the originator of the "desert libel." Yet the continent has a larger proportion of hot arid lands than any other, as shown in Table I.

Table I—Rainfall of the Continents*

(*Approximate Percentages*)

Continent	Under 20 Inches	20–40 Inches	Over 40 Inches
Australia	66 per cent largely hot	22 per cent	12 per cent
Africa	54 " " " "	18 " "	28 " "
Asia	67 " " " cool	18 " "	15 " "
North America	52 " " " "	30 " "	18 " "
Europe	47 " " " "	49 " "	4 " "
South America	16 " " " "	8 " "	76 " "

*Islands omitted.

Deserts and desert floras are not determined by rainfall alone. Köppen in his map of the climatic provinces of the earth[4] gives "desert" limits in Australia, which seem to agree with the climatic controls shown in Table II. The controls have been deduced from his map.

Table II—Rainfall and Limits of Desert*

Region	Average Annual Rainfall	Average Temperature	Season of Rain
North Australia	17 inches	77° F.	Summer
Northwest Australia	13 "	77° F.	Uniform
West New South Wales	11 "	68° F.	Uniform
Southern Lands	8 "	59° F.	Winter

*After Köppen.

[4] W. Köppen: Klassifikation der Klimate nach Temperatur, Niederschlag und Jahreslauf, *Petermanns Mitt.*, Vol. 64, 1918, pp. 193–203, 243–248. See the discussions by R. DeC. Ward: A New Classification of Climates, *Geogr. Rev.*, Vol. 8, 1919, pp. 188–191, and P. E. James: Köppen's Classification of Climates: A Review, *Monthly Weather Rev.*, Vol. 50, 1922, pp. 69–72.

Here Köppen's area agrees fairly with Gregory's most useful definition of a desert.

> The interior of South Australia is mostly a desert, using that term in its generally accepted modern meaning of a country with such an arid climate and such a scanty water supply that agriculture is impracticable and occupation is found possible only for a sparse population of pastoralists.[5]

The crux of the question lies in the meaning attached to the phrase "sparse population of pastoralists." One would imagine that few regions could be more sparsely inhabited than the million square miles of Australia charted as a desert by Köppen. An earlier section shows that there are only about 20,000 people in the half-million square miles which are at all occupied. More people may settle in these sparse regions, but the total number will always be negligible compared with that of the rest of Australia. Taking the "Northwest Division" of Western Australia (which excludes Kimberley) as typical of this type of sparse-stock country, we find that it is now almost all held as leases; there is very little for the newcomer. About 115 million acres (or 85 per cent) has been taken up, and this supports two and one-half million sheep (cattle are here not numerous). This gives 46 acres to a sheep, or 14 sheep to the square mile. A bad drought, such as that whose effect was seen in 1924, killed many. Indeed, on the trailer of the car on which the writer traveled bags of fodder from Perth were being carried to Upper Fortescue stations 300 miles inland. Here also a station manager was met who had just returned from a journey of 200 miles into the uninhabited areas in a vain endeavor to discover new cattle country. A narrow tract along the Rudall River (160 miles west of Nullagine) had been taken up but abandoned, partly because the wild aboriginals gave more trouble than the stock warranted.

About 1908 the Government of Western Australia spent much time and labor in opening up a stock route, some 800 miles long, from Hall's Creek to Wiluna (see Fig. 7). This crossed the northwest corner of the Western Desert and was made practicable by sinking wells in the south or by opening up native "soaks" in the north. About 50 wells were excavated with an average depth of 36 feet. Mr. Talbot, the well-known authority on the geology and water supply of arid Western Australia, gives an invaluable narrative of this route.[6] In the south, sand ridges, clay pan, and mulga country occur. Occasional patches of grass and saltbush are met with. North of the Tropic are wide belts of sand ridges, while the desert country terminates as Sturt Creek is reached. Talbot does not think that any of this country can be occupied by pastoralists. It is sad to know

[5] W. Howchin and J. W. Gregory: Geography of South Australia, Christchurch, 1909.

[6] H. W. B. Talbot: Geological Observation in the Country Between Wiluna, Hall's Creek, and Tanami, *Western Australia Geol. Survey Bull. No. 39*, Perth, 1910.

that this route has only once been used for stock in the fifteen years since it was opened, by two parties of drovers. The unfortunate members of the advance party were murdered by the blacks.

Carnegie[7] gives a vivid description of the enormous sand ridge area of the interior (see Fig. 2). Leaving the southern gold fields in 1896 he met the first sand ridges at 26° S. They extended north for

FIG. 3—Port Hedland (W. A.) showing the pier at the entrance to the drowned river valley. A rainfall of 12 inches is insufficient, and water is brought 40 miles by train. There is no stream now near Port Hedland: the topography indicates great recent desiccation.

420 miles. They were from 30 to 50 feet high and ran very regularly from east-by-south to west-by-north. Belts of mulga forming dense thickets and other specimens of acacia, quandong, native poplar, etc., grew sparsely in the hollows. He describes much of it as a great undulating desert of gravel formed largely of pebbles of ferruginous sandstone.

The boundaries used by the writer for the two desert regions are largely based on his own travels and research, but he has had the great advantage of their having been checked by two men with an unrivaled knowledge of the areas—Mr. Talbot in the west and Mr. W. Steele in the north and east. The latter is a well known pastoralist who has managed stations in arid New South Wales, Queensland, the Territory, and the Kimberleys. His limits of these lands "where any pastoral occupation is possible in the near future" were marked with great care on a large-scale map, and it is believed that no data of similar accuracy have so far been published.

[7] D. W. Carnegie: Spinifex and Sand, New York, 1898.

As regards the use of the word "desert" it is of interest that the large and beautifully illustrated official atlas of Natural Vegetation in the United States, 1924, (reviewed in this number of the *Geogr. Rev.*) shows almost all the following areas as desert: all Nevada, most of Utah, half of Arizona, half of Wyoming, and one-third of Oregon and Idaho. These regions are largely covered with sagebrush, creosote bush, and greasewood. Many genera such as Acacia, Atriplex, Kochia, and Salicornia are common in both deserts.

> Between the Rocky Mountains on the east and the Cascade-Sierra on the west, and extending from the Canadian to the Mexican boundary lies the great inland desert, characterized largely by xerophytic shrubs. The deserts occupy the Great Basin, except for isolated mountain forests, most of the drainage basins of the Columbia, the Snake, the Colorado and the Rio Grande. . . . In the south near the Mexican boundary the desert broadens out reaching from the Pacific nearly to the Gulf of Mexico.

Thus while there may be some difference of opinion as to whether the sparse lands are desert, it would seem that no regions better deserve the title of desert than the vast uninhabited (and under present conditions, uninhabitable) areas here termed the Western Desert and the Arunta Desert.

Comparison with the United States and Northern Africa

In forecasting the future of settlement in Australia comparison is often made with settlement in the United States. The areas of the two lands, as has been remarked, are approximately the same, but unfortunately in no other particular is resemblance close. In Figure 4 the two are placed in their appropriate latitudes with the drier lands to the west in both cases. Broadly speaking only the southern third of the United States is allied geographically to Australia, and its homologue is the southern third of Australia. But even these lands are not homoclimes (regions of similar climate), except perhaps around Sydney and Wilmington, N. C. The salient feature in the southern United States is the great area of the Gulf of Mexico running far into the land. In Australia we have an arid lowland in the same latitude, to the great disadvantage of lands still farther to the west. It is often stated that Australia's arid interior will advance by irrigation as the western region of the United States has done.[8] Apart from the great topographic differences, the irrigation regions in the United States are in very much higher latitudes—where the evaporation is relatively low and where, moreover, the rainfall in most cases is over 10 inches. Arid Mexico is perhaps a fair homoclime for the arid region (about 1200 feet high) to the southeast of Broome. Speaking gen-

[8] Cf. the note "Settlement on the Border with Government Aid" in the July number of the *Geogr. Rev.*, pp. 494–495.

erally, the United States has about five times as much temperate land with a rainfall over 20 inches as has Australia and about one-fifth as much arid country (under 10 inches). These proportions largely determine the relative economic status of the two countries.

A much closer homoclime for inland Australia is found in the only other large area of comparatively low trade-wind desert surrounded by an unbroken coast line—northern Africa. The belts of Mediterranean flora, scrub, desert, and savana agree quite closely with the similar belts in Australia. Of course the east coast of Australia has no homoclime in the Sahara. It is of interest to see that Darwin, N. T., would need to lie nearer the equator to possess a dense tropical jungle such as is erroneously shown on many maps.

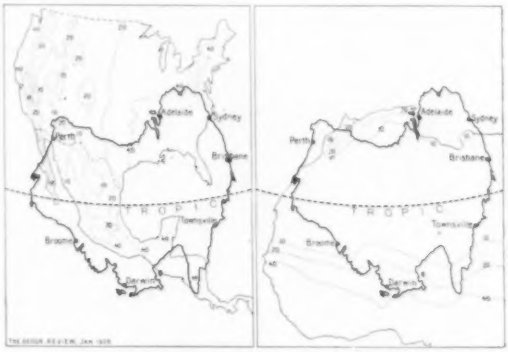

FIG. 4—Australia superimposed upon North America and upon North Africa. The American and African maps show isohyets of 10, 20, and 40 inches.

The map indicates that we must look to Nigeria for crops climatically suited to the Territory. Millets seem to be the most promising crop; but some industrial cotton may possibly be produced in favorable localities as the Queensland areas become filled up.

THE EMPTY TROPICAL LANDS

A fairly full discussion by the writer of the controls governing settlement in the Australian tropics appeared in the *Geographical Review* for August, 1919 (Vol. 8, pp. 84–115). It will not be out of place to extend that article by a few paragraphs. In the first place one must sharply differentiate the uniform-rain region of eastern Queensland from the winter-drought region of the rest of tropical Australia. Tropical products, such as sugar cane, sisal, bananas, etc., flourish here, and as a consequence 92 per cent of the inhabitants of the tropics are found in this province. The climate is too hot and muggy to be comfortable for the average Britisher. At Brisbane two months of the year have an average wet-bulb temperature exceeding 70° F. At Rockhampton (on the tropic) there are six months with over 70° F. wet-bulb. At Thursday Island every month has the conditions of discomfort thus indicated.

The Brisbane Medical Congress of 1920 devoted a short time to the problems of tropical Australia, and their formal resolutions have

been widely accepted as denying that there are any important disabilities preventing settlement in the Australian tropics. However, if the lengthy report published in the *Australian Medical Journal* for September, 1920, be examined it will be found that half of those who debated the matter at length were fully cognizant of the difficulties and not at all sanguine of success in the near future. They included many of the medical men best qualified to give an opinion.

FIG. 5.—Typical arid pastoral country on the tropic in Western Australia near Jigalong. There is no settlement east of this for 700 miles. Spinifex in the foreground, mulga by the car. Rainfall 10 inches.

Statistics of northern Queensland certainly show a satisfactory birth and death rate, but Huntington has pointed out that the population of this region is a "picked" one.[9] There are proportionately fewer women and children, and it is a matter of common knowledge that sickly and feeble folk tend to leave the tropics for the cooler portions of the Commonwealth. However, the sugar districts are progressing favorably, for the satisfactory agricultural conditions compensate for the discomfort. Large numbers of Italians are settling along the coast, and they naturally experience less discomfort than folk of British descent.

As regards the rest of the tropics, it is precisely because there are no regions offering such suitable agricultural conditions as exist in Queensland that there is no settlement. It is natural to cite the long distances and lack of communications as the chief disabilities. These did not prevent the opening up of the Queensland coast when it was as inaccessible as is Darwin today. The Territory coast lands, speaking

[9] See Huntington's review of Breinl and Young's "Tropical Australia and Its Settlement," *Annals Tropical Medicine and Parasitology*, Vol. 13, 1920, pp. 351–412; *Geogr. Rev.*, Vol. 10, 1920, pp. 110–111; and the reply, *Geogr. Rev.*, Vol. 11, 1921, pp. 474–475.

generally, are portions of an uplifted peneplain some few hundred feet above sea level. Hence there are no large areas of deep rich soil such as are found in the flood plains of China or India or Siam. The long period of dry heat which lasts from April to November tends to burn out the humus from the soils, a factor inoperative in humid eastern Queensland. The native grasses near the coast are rank and not relished by stock, while the wool of the sheep is often filled with

FIG. 6—Ooldea wells, 90 miles north of the head of the great Australian Bight. The southeastern limit of the great sand-ridge region of central Australia. The trees are largely mulgas (*Acacia*). Rainfall 8 inches.

spines and burrs. Ticks, which give rise to fever, are prevalent near the sea. These latter disabilities will diminish in the future but not until the rest of Australia is much more fully peopled than it is today.

Here also in the north the climate is not attractive to the average immigrant. Would any of the advocates of tropical settlement like to send their own families to settle at the mouth of the Congo, on the coast lands of Mexico, or on the east and south coasts of India? Yet these localities are homoclimes of Broome (Western Australia), Nullagine (Western Australia), Darwin, and Wyndham. Some of the Government publications wisely recognize the sad truth. Thus A. Despeissis writes of the Kimberleys:

> It is hopeless to expect that the north will be populated by the residents (already) there; and until the southwest [of Western Australia] produces an overflow of population that province must remain an empty territory. . . . Unfortunately it is unpleasant to record that a long sojourn in Kimberley tells on the womenfolk; and unless they are fortunately-enough circumstanced to be able to recuperate pretty frequently in the southern portion of the continent, their health often becomes severely affected.[10]

[10] The Tropical North West, Perth, 1921.

The writer sees no reasonable hope of close settlement in most of empty Australia, for the sufficient reason that Nature has not endowed it with a suitable environment. No government can alter this fact, and no spending of public money will alter the economic law that people will not occupy arid lands or poor tropical lands as long as thousands of square miles of much more attractive country are available (as they are in the east and south).

The question of an alien population is a very difficult one. Broome, the largest town in the northwest of tropical Australia, owes its existence to Asiatics, who constitute 2400 out of a total population of about 3000. There are 1200 Japanese, 500 Timorese, 300 Malays, 200 Chinese, and 150 Filipinos. Many of these are indentured sailors, who serve on the pearling fleets for two years and are then repatriated. They form a peaceable, law-abiding populace, and most of the white residents (who are chiefly merchants and pearling captains with their families) would be willing to see the system extended for labor generally.

Communications

A valuable purview of the state of settlement in Australia is gained by studying a map showing the public services provided for communication with outlying regions. In Figure 7 are shown all the main regular services in the sparsely settled regions. Through the coast lands there is railway connection from Cairns in northern Queensland to Geraldton in Western Australia. This is continuous, save for a few ferries on the east coast. From Port Augusta to Kalgoorlie this interstate railway runs through very sparsely inhabited country. There are, however, two breaks of gauge at the New South Wales borders, and three breaks of gauge between Adelaide and Perth.

Branch lines run out to the sparselands at Cloncurry, Longreach, and Charleville, in Queensland; to Collarenebri, Bourke, Cobar, Trida, and Hay in New South Wales; to Mildura, etc., in Victoria; to Broken Hill (New South Wales) and Oodnadatta in South Australia; to Laverton and Meekatharra in Western Australia. There are also a few isolated mining railways, as at Cooktown and Normanton (Queensland); to Katherine (Northern Territory); and to Marble Bar in Western Australia.

Of great geographical interest are the proposed new lines across the continent to Northern Territory. Today practically all the southern traffic from the settlements in the Territory consists of cattle droving. The cattle enter northwestern Queensland at Camooweal and thence move southward via Urandanji and Boulia to the railway at Bourke in New South Wales; or else (after a halt in southwestern Queensland) to Marree in South Australia. They rarely attempt to

cross the very poor country on the central Overland Telegraph which lies between Alice Springs and Newcastle Waters.

When Federation was agreed upon, South Australia was promised a line from Darwin to Adelaide through the northern boundary of South Australia, a promise given in ignorance of the geographical controls governing settlement. The natural outlet is from Katherine to Camooweal and thence, linking up Queensland lines, to Cunna-

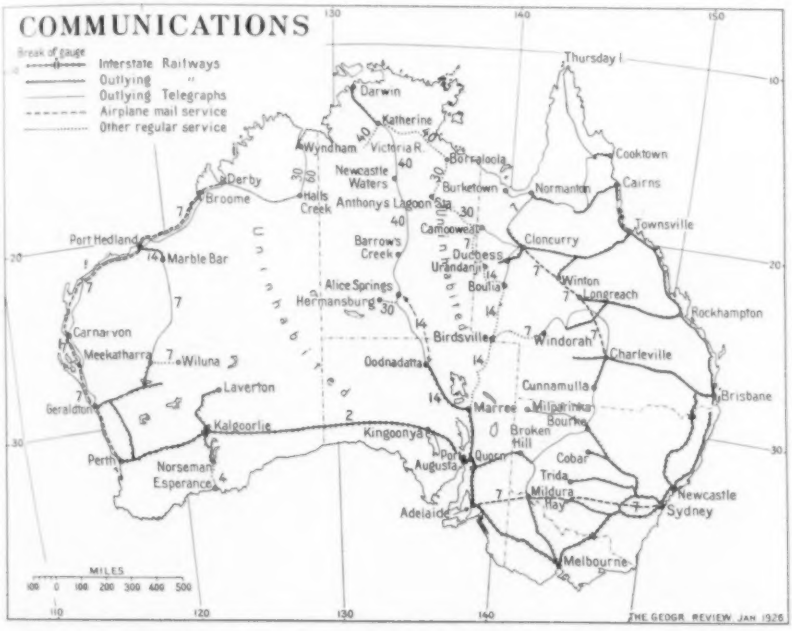

FIG. 7—Communications in the frontier regions of Australia and their main connections. Figures along the routes give the days intervening between services.

mulla and Bourke. These eastern lines must be built sooner or later, while the central north-south line via Alice Springs passes through very sparse pastoral country or unoccupied country all the way. The portion already built to Oodnadatta loses very heavily. Only one train runs each fortnight, and since 1911 a loss of over two million pounds has resulted. The railway reached Quorn in 1879 and was completed to Oodnadatta in 1891. In the last forty years no settlement of any note has grown up along its 400 miles. There are some half-dozen little townships like Hawker, Beltana, and Marree with a few hundreds of population each. Coward Springs, one of the larger northern depots, has only four houses (of which two were empty when the writer visited it in 1919) in spite of a regular service for over thirty years. At present Oodnadatta is a town of about a hundred people and the only other settlement of note until

the northern coast lands are reached is Alice Springs with an even smaller population. In every respect the suggested eastern line is superior—whether we consider total rainfall, reliability of rainfall, heat spells, pastoral occupation, access to chief population centers, military communications, or present settlement. An alternative route runs from Marree northeast to Boulia. It thus crosses the northern boundary of South Australia as the contract demands. The geog-

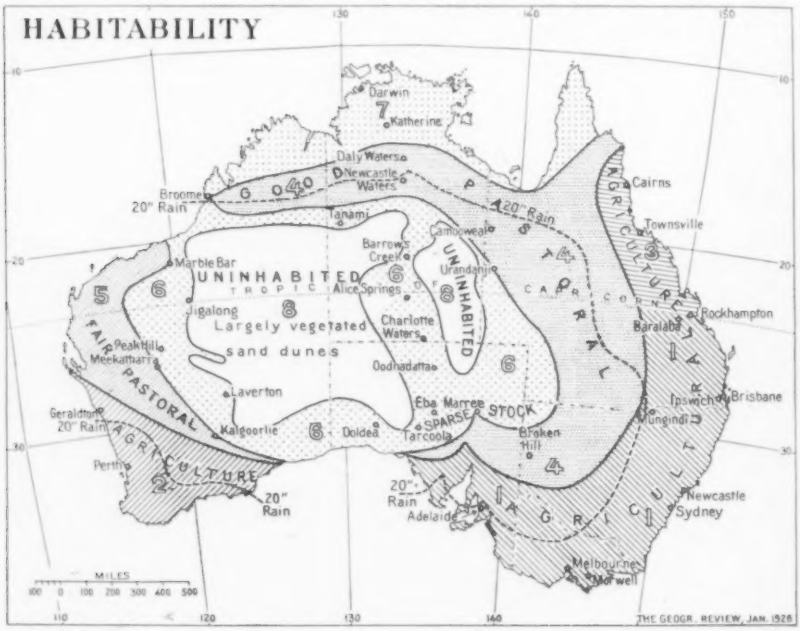

FIG. 8—A generalized habitability map of Australia. The numbers show approximate values of land in descending order from 1 to 8.

rapher's solution would be to build no through railway at all at present but to proceed slowly with the links in western Queensland as they are justified by settlement and then link up with Darwin via Camooweal at some time in the future.

Within the last year or two three long airplane services have come into successful operation. The longest extends from Perth (Western Australia) to Derby, about 1300 miles. The weekly service is run in three relays to Broome, whence a flight to Derby (100 miles east) is made every Saturday. It is proposed to extend it shortly to Wyndham and Darwin.

The second service travels weekly from Charleville to Cloncurry in western Queensland, a distance of about 600 miles. The third has recently started from Sydney to Adelaide. Five hours' flying in the afternoon of Saturday brings the airplane to Hay. On Sunday Ade-

laide is reached in the same time. A return is made on Monday and Tuesday. The service is weekly.

The remaining important routes usually follow telegraph lines. Thus the Overland Telegraph from Oodnadatta to Katherine (completed in 1872) indicates the route of the mail which reaches Alice Springs from the south each fortnight, and from the north every six weeks. A motor car runs weekly from Meekatharra to Marble Bar

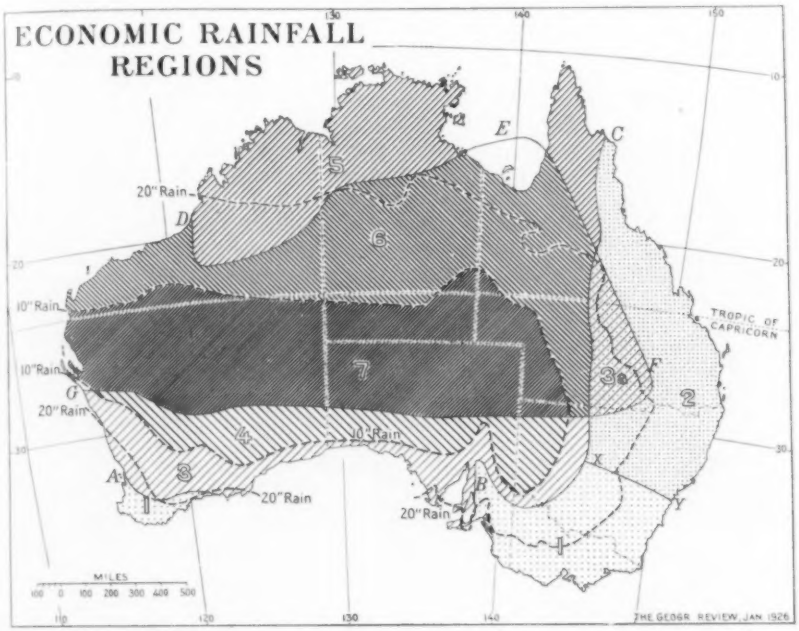

FIG. 9—Economic rainfall regions of Australia. Areas south and east of *ABC* have fairly uniform rainfall, i. e. a monthly rainfall of over 1 inch during more than two-thirds of the year. The area within *DEFG* is unreliable, varying on an average 30 per cent from the normal. The remaining areas have seasonal but reliable rainfall. Areas with less than 10 inches of rain are very arid. The regions are characterized thus: 1, uniform with winter maximum; 2, uniform with summer maximum; 3a, erratic; 3, moderate winter rains; 4, rare winter rains; 5, summer rains; 6, light summer rains (much is arid); 7, rare summer rains.

in the north of Western Australia. A mail service goes every month in winter from Wyndham to Hall's Creek and every two months in the wet summer. Coaches or pack horses carry the mail from Marree (South Australia) to Boulin (Queensland) every fortnight; while one of the most isolated services is by pack horse every month from Camooweal to Borroloola (on the Gulf of Carpentaria), whence one can reach Katherine every six weeks.

As regards the rest of Australia, the motor car is ubiquitous except in the totally unoccupied districts; but the main lines of regular communication in the sparselands are fairly thoroughly covered in the map herewith.

Settlement in the future must spread out normally from present-day settlement. No marked change can be expected in view of the fact that population in the sparselands has been stagnant for a quarter of a century, except in a few mining towns. Thus it seems to the writer quite possible to draft a map of land values to show the regions that will best repay outlay of public moneys. A tentative effort is given in Figure 8.

It is instructive to compare this map with the rainfall map (Fig. 9). Agriculture is confined to the uniform rain regions and to rain regions where the reliable winter rain and low evaporation make wheat growing possible. The good pastoral region is found in the wetter portion of rain region 6 and in the drier portions of the uniform-rain regions and of rain region 5. From this it follows that season of rain and even reliability of rain are not vital as regards stock provided the total amount is sufficient. This sufficiency amounts to about 16 inches on the north and about 9 inches in the south of the continent. When one realizes that in Australia stock thrive on natural hay (that is dead grasses still rooted to the ground) and on top feed (mulga, etc.), it is natural for considerable variations in rainfall to be successfully withstood.

As regards the settlement regions labeled "sparse stock" and "uninhabited," rainfall is only one of the major factors. For instance, the coastal portion of the worst rainfall region (7) carries a small number of sheep and cattle. This should not surprise us, for the natural habitat of such stock is precisely the steppe country bounding the deserts of the Old World. In a wild state in years of good rainfall the stock graze farther into the dry areas; in years of drought many die; but the rest survive by moving away from the desert. We are told that the Saharan desert supports millions of stock.

The determining factor in Australia in this region is geological or at any rate edaphic. It is possible to graze stock almost everywhere, even near Lake Eyre (where only four inches of rain falls), provided that the country is not covered with sand ridges. In the latter the vegetation and water supply are too scanty for profitable occupation under present conditions. Hence we see that the great western desert area is bounded on the east and west sides by lines which run across all the dominant rainfall isopleths. But it seems probable that the northern and southern boundaries are controlled by rainfall. Apparently 16 inches of summer rainfall, with an evaporation of about 110 inches (as in the north), gives a pastoral environment about equivalent to 8 inches of winter rainfall and about 70 inches of evaporation in the south. Possibly the writer's suggestion is somewhat speculative, but it looks as if five inches of evaporation would nullify

from an economic viewpoint about one inch of rainfall in this central arid region.

No doubt some day the half-million square miles of our deserts will support some stock. But the deserts are greatly inferior to the sparselands and by analogy are never likely to support one per cent of Australia's total stock. For the same reason it seems probable that the human population in this central area will never be aught but negligible.

General Survey of the Fringe of Settlement

In the course of the last five years it has been the good fortune of the writer to travel, on one occasion or another, almost all through the regions of negligible population, from Roebuck Plains near Broome in the Kimberleys (Western Australia) via Kalgoorlie (Western Australia), Lake Eyre (South Australia), Broken Hill (New South Wales), Angledool (New South Wales), and then via Rockhampton along to the northwest of Queensland through Winton and Camooweal (Queensland) to Avon Downs in the Northern Territory.

A brief account of the geographical features met with on such a journey will enable the reader to appreciate the conditions in "empty Australia" that have retarded settlement on the frontiers.

SOUTH KIMBERLEY

The region around Broome consists of low sandy plains with a rather erratic rainfall of 20 inches, falling wholly in summer. The average temperature is about 80° F. The vegetation is rather sparse owing to the dry winter, but some tropical trees, for example the baobab and pandanus, are found in favorable localities. The characteristic covering is *pindan*, a scattered, open forest of acacias, *Bauhinia* (family Leguminosæ), cajuput (family Myrtaceæ), and bloodwood. These trees grow about 20 feet high. Some of the wattles (*Acacia*) and the pods of the *Bauhinia* constitute good "top feed" which lasts through drought. In good seasons there is a considerable amount of grass and herbs, which become much more extensive in the great plains of the Fitzroy River. This is excellent cattle country but is rather too hot for sheep. There is no agriculture, and the town of Broome (with 70 per cent colored Asiatic population) depends almost wholly on pearling. The Fitzroy River flows most of the year. Elsewhere it is not difficult to obtain water from shallow wells by windmills or pumps.

DESERT OUTLET

The Desert Outlet region is characterized by an erratic summer rainfall of 15 inches. Although not the driest coast in Australia, this stretch

of 300 miles is perhaps the least attractive. Here the constant southeast trade winds blow the sands of the sand ridge desert into the ocean, just as is the case to the west of the Sahara. The writer made the journey by airplane, whence he had an excellent view of the streaks of yellow and red dust extending for miles over the waters of the pearling grounds. It seems possible that the shallowness of the sea is in large part due to this secular filling. Only a fringe of country a few miles wide is occupied at Wallal by cattle stations, and there is no other settler for a thousand miles to the southeast until the Overland Telegraph is reached at Barrow Creek. The temperature here is excessive. At Marble Bar, just to the south, the thermometer has been known to rise daily above 110° (on an average) for three and a half months. Government wells are sunk on the stock route along the coast. Elsewhere there is no settlement.

PILBARRA

The boundary of settlement is the great rabbit-proof fence which runs southward from Condon to the Australian Bight a thousand miles away. It is regularly patrolled to keep the rabbits from entering the pastoral areas to the west. As far as I could ascertain it is not of very much use, for the rabbits have passed through; and in the huge cattle stations nearer the coast there are practically no subdivision fences to isolate them. The De Grey River flows only at long intervals. One of its tributaries had not run for nine years at the time of my visit. To these valleys the term "wadi" might well be applied. Ground water at 50 feet or so is not difficult to obtain. Much of the country is covered with rock waste interspersed with spinifex tussocks (*Triodia*), up to ten feet across and a great standby for sheep in drought. Pigweed, vetch, and other herbs flourish after rains, but grass is rare. The country is ranged by sheep on stations containing about 200,000 acres each.

THE SAND RIDGE DESERT

The writer entered the western margin of this huge terrain near Jigalong, an outpost settlement in central Western Australia. It is remarkably level, the surface rarely varying much from 1200 feet above the sea. Here were low sand ridges, fixed by a vegetation consisting of spinifex, mulga, *Eremophila*, and small eucalypts. It differed rather in degree than in kind from the occupied areas to the west, but the feed was much poorer and the water supply most precarious. So far the sand ridges have been recognized as bounding the territory which is capable of even sparse pastoral occupation. The rainfall of this huge tract varies from 8 inches in the south to 17 inches in the north. The evaporation is over 100 inches.

THE MURCHISON REGION

This area is of a late mature topography, at an elevation of about 1200 feet. Mulga is almost universally distributed; and ground water can often be obtained about 50 feet down. A little spinifex is present in the sandy areas, while saltbush (*Atriplex*, etc.) is a useful fodder in places. But the cattle in dry seasons subsist almost wholly on the mulga top feed. The rainfall is very low and unreliable, being only about 8 inches at Meekatharra. Rain falls partly in winter, partly in summer. Rock waste is common, but sand ridges are practically absent. Almost all the available land is now held in pastoral leases, and the great stock route from the north reaches the end of Australia's connected railways at Meekatharra. Cattle are grazed in the northern, and sheep in the southern portions of this region.

SWANLAND

As soon as the 10-inch line is approached to the southwest a much denser vegetation develops. Close-set mulgas and heathlike shrubs are interspersed with eucalypts thirty feet high. This growth is rendered possible by the unusually reliable winter rains of this corner of Australia. We touch here the edge of the agricultural belt. Wheat is sown on the fringe and occasionally the rain is sufficient to enable the wheat to ripen. Often, however, it is cut for green fodder. At 11 inches (near Burracoppin) wheat is grown successfully, so that hereabouts at the 10-inch line one passes rapidly from a sparse pastoral region to one capable of fairly close settlement. The wetter portions of Swanland (10 to 40 inches) are excellent farm lands in general.

WESTERN AUSTRALIA GOLD FIELDS

The physical controls here resemble those on the borders of the two preceding regions, with similar results as regards vegetation. The rainfall is under 10 inches but more reliable. On the other hand the ground water is often saline, and there is very little pastoral occupation along the Transcontinental Railway at present. It would seem to have a future as a sheep region when the lack of ground water and the dingo pest are overcome. A noteworthy feature of settlement is the dismantling of the large town of Coolgardie with the closing of the mines. Kalgoorlie-Boulder is still a flourishing town of 16,000 people, watered by the 33-inch pipe line from the coast.

NULLARBOR

Here is a region with a reliable 10-inch rainfall, a good climate, and a fair saltbush cover readily eaten by stock. Yet there is practically no pastoral occupation because the surface consists of porous

limestone, which renders it almost impossible to conserve water for stock. There is an artesian supply, which is, however, too saline for use in large areas of this treeless plain. The southeastern limit of the great sand ridge desert extends to Ooldea from Wallal and Jigalong where we noted it on the northwest. It is crossed by the Transcontinental Railway.

LAKE EYRE

This is a lowland region in which an area of some 70 by 120 miles, including the lake bed and part of the railway, is below sea level. For some 200 miles to the south of Lake Eyre, itself a great expanse of salty mud, there are many other *playas*, or salt lakes. The erratic rainfall varies from 4 inches to 8 inches a year, falling chiefly in the winter. Mulga and saltbush grow abundantly on the wetter margins, and occasionally large swamps support a number of cattle. But the drier region (under 6 inches) is largely covered with sheet waste of pebbles, gibbers, showing "desert varnish." Sparse saltbush exists, but no trees except the eucalypts along the dry creek beds. The frontier "station" (ranch) here is Crown Hill,[11] comprising 2560 square miles. Huge beds of gypsum occur in the ranges, and this salt is present in the soils in large amounts. Yet nature, in compensation, has furnished an underground supply in the form of the Great Artesian Basin reaching from Eastern Queensland almost to Crown Hill. The natural outlets form "mound springs" all along the railway line from Marree to Oodnadatta. The country is sparsely taken up for cattle, dingoes having recently ruined the former sheep industry hereabouts.

BROKEN HILL REGION

Here a recent buckling of the crust has raised an earth block about 1000 feet above sea level, constituting the Barrier Ranges. The rainfall is about 9 inches and is erratic though fairly uniform as regards season. Saltbush is perhaps the dominant cover in the west, forming good feed for stock. In this region also the dingoes kill the lambs, and this is responsible for a temporary change-over from sheep to cattle. Mulga is the chief tree, and associated with it are smaller trees such as *Eremophila*, *Fusanus*, *Myoporum*, etc. Close-set mallee scrub (*Eucalyptus dumosa*) is common in the south, where the rain falls more largely in winter. This scrub, south of the Murray River, tends to give place to wheat where there is a rainfall of 11 or 12 inches. Many bushes, such as burrawang, kurrajong, "rosebush," etc., are useful for fodder in the wetter 12-inch portion east of the Darling River. Here also the eucalypts (*E. populifolia*) replace the acacias.

[11] See the photograph in *Geogr. Rev.*, Vol. 8, 1919, p. 294, Fig. 4.

FIG. 10

FIG. 11

FIG. 12

FIG. 10—Coward Springs at the southwest corner of Lake Eyre. The water is waste from a natural mound spring whose mound is 30 feet high. In the background is a (Pleistocene?) fossil mound spring 200 feet high, indicating a great diminution in the outflow of artesian water.

FIG. 11—Coward Springs Depot, showing the fortnightly train proceeding north to Oodnadatta. The railway has been built for over 30 years, but practically no settlement has resulted.

FIG. 12—Emu Creek, 60 miles southwest of Lake Eyre (S. A.). Very poor "gibber" country with a rainfall of 5½ inches a year. Note the eucalypts in the dry creek bed and the mesas of "desert sandstone" in the background.

The Darling River is intermittent and of late years has ceased flowing for 18 months at a time. The writer has shown a remarkable correlation between the drought years at Bourke and the sun-spot cycle, which perhaps explains the increasing aridity here since 1875.[12]

BARWON REGION

This is largely an area of black-soil plains about 400 feet above sea level in which the larger rivers of Pleistocene times deposited a deep rich alluvium. It is clothed with an open eucalypt forest which contains other interesting forms such as the native orange and leopardwood (*Flindersia*). The latter is allied to the teaks and seems to have spread west during the wetter Pleistocene conditions and to have adapted itself to the succeeding desiccation. The country is almost wholly devoted to merino sheep; and the artesian water has been led from the bores by radiating drains in order to water paddocks 20 or 30 miles away. The rainfall is 15 or 20 inches, but the increased evaporation and the absence of winter rains restricts the eastern agricultural belt, which does not enter this district.

GREGORY REGION

This is a region of about 600 feet elevation crossed by the broad, usually dry, channel of the Barcoo and Diamantina Rivers. The rainfall is very erratic and is from 8 to 15 inches, falling chiefly in summer. Saltbush now gives place to various grasses, such as blue grass (*Andropogon*), with much Mitchell grass (*Astrebla*) in the north. The grassy plains are crossed by belts of various species of acacia, especially in the wetter hollows. Eucalypts and other Myrtaceæ are relatively rare. In the wetter east, the border of which is the only part traversed by the writer, the acacia thickets (scrubs) become denser and wider. Here brigalow (*Acacia harpophylla*), growing 15 to 20 feet high, is perhaps the commonest. Sheep are grazed extensively, and the value of the artesian water cannot be overestimated. Several bores are over 5000 feet deep and have a flow of more than 3,000,000 gallons daily.

BARKLY REGION

This is usually termed a table-land but is indistinguishable from the general peneplain at 900 feet elevation except where its northern scarp drops to the Gulf of Carpentaria. The rainfall varies from 10 to 20 inches per year, falling wholly in summer. In the east a somewhat rugged inlier of ancient rocks includes the Cloncurry mineral fields. Here the arenaceous rocks are sparsely covered with spinifex,

[12] Griffith Taylor: Geography and Australian National Problems, *Australian Assoc. for the Advancement of Sci.*, Vol. 16, 1923, pp. 433–487; reference on p. 444.

FIG. 13

FIG. 14

FIG. 13—Duchess, a small mining town in Northwest Queensland. Note the grass-covered rock floor and the Inselberge, probably indicating a former more arid cycle.

FIG. 14—Avon Downs, cattle station in the east of Northern Territory showing the Barkly Tableland pastoral country. The bare foreground is worn by traffic.

"snapping gum" (Eucalyptus), and huge termite nests. This type of country is of little use for stock and is locally termed "desert" whatever the rainfall. The level western portion consists of prairies of Mitchell grass and clumps of small trees such as gidgee (*Acacia*), whitewood, and beefwood (*Grevillea*).

On the edge of civilization is the little township of Urandanji. There is no habitation for eleven hundred miles to the west until we reach Wallal on the Indian Ocean, except in one spot at Barrow Creek (some three hundred miles away) on the Overland Telegraph. Urandanji has a rainfall of 10 or 11 inches, which is very low for such a hot locality. It lies a hundred and fifty miles on the hot side of the Tropic of Capricorn, and its average temperature is 75°. It consists of a large hotel, two stores, the post office, and half a dozen houses. Its *raison d'etre* is that it lies on the great stock route from the Northern Territory to South Queensland, New South Wales, and South Australia. Water is obtained by wells in or near the gravels of the intermittent Georgina River.

One feature of great interest in the wetter portions of this district is that large areas are apparently covered with sheet waste, through which springs up abundant Mitchell grass. Moreover the region near the railway terminus at Duchess (Fig. 13) has also the characteristic appearance of arid erosion. Inselberge of quartzite rise sharply out of flat rock floors, which again support a covering of grass in the sparse soils. The writer came to the conclusion that these features indicated that an arid cycle of erosion has given place to the normal cycle within a relatively recent geological period. This would support Penck's theory of the shifting desert belts.

Water is obtained by wells one or two hundred feet deep in many parts of the table-land. Future settlement is almost entirely controlled by the cost—£500 to £1000 each—of sinking and equipping such wells. A well will water a radius of about eight miles in cattle country. All this region in the Territory is devoted to cattle: the sheep originally stocked have been sold off largely because of the increase in labor costs and the difficulty of transporting the wool.

VICTORIA RIVER REGION

This region, the sole area in these marginal lands unvisited by the writer, may be taken to include the best part of the Northern Territory except that discussed above. It extends from Newcastle Waters to the Kimberley region of Western Australia. The general level is about 800 feet, and the region is marked by a number of basins of internal drainage, for example Lake Woods. These hollows are not salt *playas* but at times are filled with fresh water. They support the theory of decreasing desiccation in the north, discussed previously.

The rainfall is 20 to 25 inches a year, all falling in the four hottest months. The soils are rather poor as a whole, and recent surface formations of laterite, travertine, and quartzite are abundant. Limestones and basic eruptives, however, give rise to some large areas of better soil, which support Mitchell grass, *Bauhinia*, bluebush (*Kochia*, etc.). The arenaceous tracts are covered with spinifex (*Triodia*) and thickets of mulga, etc., with some stunted eucalypts. The sole industries are cattle raising and some unimportant mining.

Summary

Nature has placed Australia precisely where the trade wind arid areas can occupy the largest portion of its surface. Under these circumstances the continent must always be largely a pastoral region. The following statement[13] sums up the problem.

About 42 per cent of Australia is *arid*; of which 20 per cent of the whole is *almost useless* for stock and 22 per cent is *fair pastoral country* except in drought years. About 34 per cent is *good pastoral country;* about 21 per cent is *fair temperate farming country* (but it contains almost all the rugged mountain areas), 13 per cent receiving over 20 inches of rain and 8 per cent less than 20 inches. About 3 per cent (in tropical Queensland) is suitable for tropical agriculture (excluding the mountains).

There is probably room for 20 million folk in the east and south, engaged in agriculture and manufactures, before any serious congestion can arise. Hence, in the writer's opinion, the necessity for settling the arid and tropical sparselands does not seem to be at all urgent.

[13] See the writer's "Australia in Its Physiographic and Economic Aspects," 4th edit., Oxford, 1925, p. 263.

OCEANIC AND CLIMATIC PHENOMENA ALONG THE WEST COAST OF SOUTH AMERICA DURING 1925

Robert Cushman Murphy
American Museum of Natural History

THE winter and spring of 1925 witnessed a remarkable change in the customary weather of the arid west coast of South America. In one part of the coast or another occurred a reverse flow of the ocean currents, abnormally high temperatures of the sea water, and torrential rains. The destruction of marine life due to the warming of the ocean and, more particularly, the serious economic effects of rainfall in a "rainless" region have been featured in the newspapers and the accounts often colored by fantastic interpretations.

The writer was in Peru and Ecuador from December 8, 1924, until March 12, 1925, on behalf of the American Museum of Natural History. From the early part of January until the end of this period he was engaged, with the assistance of Mr. Van Campen Heilner, in a continuation of the marine zoölogical work hitherto reported upon in the *Geographical Review*. The purpose of this article is to consider the events of an extraordinary season in the light of observations made in the field and to correlate these with such data as we could gather from many sources, principally through the kindness of friends in South America.[1]

The Normal Phenomena

The normal climate and hydrography of the central zone on the Pacific coast of South America are now well known, at least in outline. Along the shore line extending from the outer parts of the Gulf of Guayaquil southward to the vicinity of Valparaiso, Chile, the prevailing winds are southerly, the inshore waters of the north-

[1] The writer is indebted to the following persons for assistance in the field or subsequent information: Mr. Bruce Dunlop, manager of the station of the International Petroleum Co., Ltd., at Talara, for the use of launches and many other facilities; Messrs. L. M. Stone, William Light, J. L. Stauft, and A. A. Olsson, of the same organization, for similar coöperation and for temperature data covering two years; the Hon. Miles Poindexter, U. S. Ambassador to Peru, for new meteorological information compiled from many sources, and Miss Harriett Meek, of the Embassy staff, for transcribing the same; Mr. G. S. Dexter, captain of the Grace liner *Santa Luisa;* Mr. C. N. Griffis, editor of the *West Coast Leader*, Lima; Col. E. Lester Jones, director, and Commander G. T. Rude, of the U. S. Coast and Geodetic Survey; Capt. F. B. Bassett, hydrographer of the U. S. Navy, and several of his associates in the Hydrographic Office; Dr. C. F. Marvin, chief of the U. S. Weather Bureau; and various others, some of whose names are mentioned in the following pages.

ward-flowing Humboldt Current are remarkably cool and unvarying, and the seaward slopes of the mountains as well as the littoral ocean for more than a hundred miles from shore are, in the ordinary sense of the word, rainless. As a corollary of these conditions, the terrestrial biota is relatively poor, while marine life is both extraordinarily rich and delicately adjusted to the environment. Many aspects of the region have been discussed, with full citation of earlier authorities, by Bowman, Jefferson, and Murphy.[2] The writer's former paper in the *Geographical Review* is, indeed, the basis of the present contribution.

FIG. 1—Sketch map of part of the coast of Ecuador and Peru showing localities mentioned in the text. The dotted line is the divide of the Western Cordillera.

THE COUNTERCURRENT AND OCEAN TEMPERATURE RELATIONS

El Niño, the warm countercurrent, is a well known phenomenon in northern Peruvian waters, commonly appearing about Christmas time and flowing southward. The more or less annual effects of the countercurrent are, as a rule, observable only in northernmost Peru. During a longer cycle, traditionally believed to be seven years, but less evident recently than in former times, its manifestations are more pronounced and extensive. At still longer intervals, representing in the present instance a rhythm of thirty-four years, *El Niño* and its associated phenomena attain their maximum expression. The combined effects during the early months of 1925 were far greater than those of any season since 1891 and probably greater than in any year of record. Many recorded data give the norm of the sea water temperature of the north Peruvian coast. Observations made from the U. S. S. *Utah* on the direct course from Balboa to Callao in December, 1924, may serve as an especially pertinent example because of their closeness to the time of the oceanic transformation. At one-half a degree north of the equator, on Decem-

[2] Isaiah Bowman: The Andes of Southern Peru, New York, 1916 (especially pp. 143–145).
Mark Jefferson: The Rainfall of Chile, *Amer. Geogr. Soc. Research Ser. No. 7*, 1921, pp. 1–32.
R. C. Murphy: The Oceanography of the Peruvian Littoral, *Geogr. Rev.*, Vol. 13, 1923, pp. 64–85.
R. C. Murphy: Bird Islands of Peru, New York, 1925.
See also A. G. Ogilvie: Geography of the Central Andes, *Amer. Geogr. Soc. Map of Hispanic America Publ. No. 1*, 1922.

ber 3, the temperature observed from the *Utah* was 79° F. In latitude 3° S. it had dropped to 76° F.; off Cape Blanco the upwelling water of the Humboldt Current had lowered it to 66° F., a figure which in turn gave way to 64° F. in latitude 9° S., on December 5.

During the first two weeks of January, 1925, conditions were normal along the whole coast of Peru. The countercurrent from the north reached the latitude of Talara, 5° 45′ S. about January 18, 1925, as first shown by a sudden rise in temperature of the surface of the ocean.[3] During a ten-day period the general increase amounted to about 12° F., the thermometer standing at 77°–78° F. on January 27. On January 21 the countercurrent was measured instrumentally as it ran strongly past Point Pariñas.[4] On January 19 the first spatter of rain reached the coast at Talara, and on January 27 the rainy period may be said definitely to have begun. The precipitation was not of the shower type but was fairly heavy and continuous.

By the second week of March the current produced such unheard-of surface temperatures as 80° F. in the harbor of Callao (Tables II and III), 79° F. near Mollendo, and 70° F. at or near the ports of Antofagasta and Valparaiso.[5] The accompanying tables (I–VII)[6] give an idea of the extent of the change. Comparison should be made with data for normal periods such as are given by Coker[7] and by the writer in his earlier paper in the *Geographical Review*.

By the middle of April a return to normal, first evident along the southerly part of the coast, was well under way, a process which was completed during May. Recording thermometer charts indicate a decrease of 6° F. in the weekly maxima of the water of Talara harbor during the month ending May 23. Captain G. S. Dexter of the *Santa Luisa* reported temperatures of 68° at Callao and 66° at Pisco at the end of April. Writing on May 26 at the conclusion of a voyage to Chile he further states that:

"The Humboldt Current is gradually getting back to normal. Off the headlands we found the water quite cool again, and we met considerable northward setting current."

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[3] A detailed account of the appearance of the countercurrent at Point Pariñas, together with the advent of northerly winds and of premonitory signs of rain which descended very gradually from higher levels to the coast, has been given by the author in "Equatorial Vignettes," *Natural History*, Vol. 25, 1925, pp. 431–449. See also the table of temperatures of both air and sea obtained by Mr. Heilner and the writer in the *Monthly Weather Rev.*, Vol. 53, 1925, p. 116.

[4] The instruments employed during the field work were the same as those described in the *Geogr. Rev.* of January, 1923, except that the current meter was replaced by an adaptation of the chip log recently devised by the U. S. Coast and Geodetic Survey. This proved both simpler and more accurate than the meter. The hydrometers used for density determinations were likewise supplied by the Survey.

[5] See the table of temperatures recorded by the *Santa Luisa* (Captain G. S. Dexter), March 6–27, published in the appendix to Mr. F. C. Walcott's paper "An Expedition to the Laguna Colorada, Southern Bolivia: With a Note on the Recent Occurrence of El Niño," *Geogr. Rev.*, Vol. 15, 1925, pp. 345–366.

[6] Data chiefly from the files of the U. S. Hydrographic Office.

[7] R. E. Coker: Ocean Temperatures Off the Coast of Peru, *Geogr. Rev.*, Vol. 5, 1918, pp. 127–135.

Cooler water *off the headlands* is always an indication of upwelling. The low temperatures of the Humboldt Current near shore are due to this cause. As a point of importance regarding Tables I–VII, it should be emphasized that the routes of all the vessels cited lie within this zone of coastal upwelling. The high temperatures imply, therefore, a truly exceptional state of the littoral waters; they have no relation to conditions in the outlying Pacific where, at fifty or more nautical miles from shore, warm surface temperatures obtain throughout the year.

Several of the tables (II, III, VI, VII) indicate that during the flow of *El Niño* the surface water along the steamship lanes between Panama and the Gulf of Guayaquil was slightly though uniformly cooler than that farther south. This circumstance is the opposite of what might be expected, but it was confirmed by observations made by Mr. Heilner and the writer in the equatorial region to the northward of Cape San Lorenzo, Ecuador. It is interesting as suggesting the actual source of the warm water which bathed the Peruvian coast. In the southern hemisphere, northerly

TABLE I—CANADIAN S.S. "CALGAROLITE," BOUND TOWARD ARICA, JAN., 1925

DATE	POSITION *Lat.*	*Long.*	TEMPERATURE
Jan. 29	10° 49′ S.	78° 40′ W.	75° F.
?	11° 32′ S.	78° 09′ W.	74°
?	17° 07′ S.	72° 50′ W.	74°
?	Arrived at Arica		71°

TABLE II—AMERICAN S.S. "SANTA ELISA," ANTOFAGASTA TO BALBOA, MARCH, 1925

PORT OF CALL	4 a. m.	8 a. m.	Noon	4 p. m.	8 p. m.	Midnight
March						
8 Iquique					64	
Arica		**68***				
9 Mollendo		72	78	**78**	72	64
10 Pisco	66	67	70	**72**	74	76
11 Callao					**80**	
12 Salaverry	82	82	82	**82**	82	82.5
13 Talara	74	82	83	**80**		
Off Gulf of Guayaquil						82
14 Off Point Santa Elena	82.5					
West of La Plata Island		82				
90 m. N. of La Plata I.				76		

*Boldface figures are temperature readings taken at or near the port of call.

TABLE III—CANADIAN S.S. "MONTROLITE," CUBA TO TALARA AND CALLAO, MARCH, 1925

DATE	POSITION *Lat.*	*Long.*	TEMPERATURE
March 9	6° 07′ N.	79° 53′ W.	73° F.
	4° 53′ N.	80° 15′ W.	73°
" 10	2° 42′ N.	80° 25′ W.	74°
	1° 37′ N.	80° 27′ W.	77°
	0° 26′ N.	80° 43′ W.	79°
" 11	1° 15′ S.	81° 14′ W.	79°
	2° 40′ S.	81° 17′ W.	80°
	Talara Harbor		80°
" 13	5° 19′ S.	81° 19′ W.	81°
	6° 52′ S.	80° 37′ W.	80°
" 14	8° 48′ S.	79° 20′ W.	81°
" 15	Callao Bay		80°

TABLE IV—JAPANESE S.S. "ATLANTIC MARU," BALBOA TO CHILEAN PORTS, MARCH, 1925*

DATE	POSITION *Lat.*	TEMPERATURE
March 9	0° 35′ N.	76° F.
" 10	1° 25′ S.	78°
" 11	6° 30′ S.	77°
" 12	10° 15′ S.	78°
" 13	13° 40′ S.	73°
" 14	17° 15′ S.	75°
" 15	20° 30′ S.	75°
" 16	23° 25′ S.	70°

*Positions have been approximated from a plotted chart.

TABLE V—NORWEGIAN S.S. "CAMILLA GILBERT," NORFOLK TO TOCOPILLA, MARCH, 1925

DATE	POSITION *Lat.*	*Long.*	TEMPERATURE
March 15	5° 15′ N.	80° 19′ W.	81° F.
" 16	0° 57′ N.	81° 32′ W.	79°
" 17	3° 23′ S.	81° 40′ W.	82°
" 18	7° 24′ S.	81° 13′ W.	84°
" 19	11° 11′ S.	79° 07′ W.	81°
" 20	14° 39′ S.	77° 06′ W.	76°
" 21	17° 02′ S.	75° 10′ W.	73°
" 22	19° 31′ S.	72° 57′ W.	74°
" 23	21° 44′ S.	70° 33′ W.	77°

TABLE VI—AMERICAN S.S. "MINEOLA," TALCAHUANO TO BALBOA, MARCH, 1925

DATE	POSITION *Lat.*	*Long.*	TEMPERATURE
March 11	34° 42′ S.	72° 47′ W.	64° F.
" 12	30° 32′ S.	71° 56′ W.	64°
" 13	26° 44′ S.	71° 17′ W.	68°
" 14	22° 51′ S.	70° 39′ W.	64°
" 18	16° 18′ S.	74° 33′ W.	72°
" 19	13° 45′ S.	76° 43′ W.	68°
" 20	10° 50′ S.	78° 09′ W.	82°
" 21	7° 47′ S.	80° 01′ W.	81°
" 22	4° 23′ S.	81° 24′ W.	82°
" 23	0° 23′ S.	81° 03′ W.	82°
" 24	3° 14′ N.	80° 25′ W.	82°
" 25	6° 34′ N.	79° 39′ W.	72°

winds tend to drive the surface water not directly before them but at an angle to the left. This accounts for the heaping up of warm, offshore Pacific water along Peru after the cessation of upwelling, which is always active during sustained southerly winds. North of the equator, on the other hand, winds from a northerly quarter tend to drive the surface water toward the right, or off a western shore. This, together with the possible inception of upwelling along the coasts of Colombia and northern Ecuador, is doubtless the factor which accounts for the lower surface temperatures observed in the great bight between Ecuador and the Isthmus of Panama.

THE COUNTERCURRENT AN ACTIVE PHENOMENON

That the phenomenon of *El Niño* was not a merely passive condition due to the temporary cessation or deflection of the Humboldt Current we have abundant evidence from the effects upon shipping. Between late January and April all steamers from Peruvian and Chilean ports were behind their schedules on reaching Panama. One fast passenger vessel lost ten hours on the stretch of 817 miles between Talara and

Balboa, during a trip ending March 27. The "negative slip" was equally observed by craft northbound along northern Chile and southern Peru. The strength of the countercurrent, as based upon the ratio of speed and engine revolutions in five steamers, varied between one-half and a little less than two knots, the highest velocity being recorded near Callao on March 11.

Instrumental measurements made by Mr. Heilner and the writer from one to nineteen miles off Point Pariñas on January 21 showed a southward rate of from one to one and one-quarter knots against the prevailing wind during a ten-hour observation period. Nearly identical results were obtained west of Point Santa Elena, Ecuador, on February 21.

TABLE VII—BRITISH S.S. "OROYA," BALBOA TO CALLAO, MAY, 1925

DATE	POSITION *Lat.*	POSITION *Long.*	TEMPERATURE
May 15 8 a. m.	7° 12′ N.	79° 45′ W.	79° F.
" " 8 p. m.	4° 29′ N.	80° 14′ W.	82°
" 16 8 a. m.	1° 38′ N.	80° 32′ W.	82°
" " 8 p. m.	1° 10′ S.	81° 13′ W.	79°
" 17 8 a. m.	3° 39′ S.	81° 20′ W.	74°
" " 8 p. m.	6° 21′ S.	81° 08′ W.	69°
" 18 8 a. m.	8° 22′ S.	79° 24′ W.	67°
" " 8 p. m.	10° 38′ S.	78° 05′ W.	66°

It is a matter of regret that no depth temperatures taken along the Peruvian littoral during the activity of the countercurrent have come to light. The *Arcturus*, which was admirably equipped for such observations, appears not to have voyaged sufficiently southward or near the coast to carry them out. A cross section of subsurface temperatures, even without direct current measurements, would no doubt answer the much discussed question as to what actually occurs when a deep, cool, coastwise stream is opposed by the meteorological and oceanic complex associated with the advance of *El Niño*. Does the Humboldt Current for the time cease to exist? Is it deflected to westward, as is widely credited, though without a shadow of evidence? Or does it hold to its course beneath a relatively shallow layer of the equatorial counterflow?

SECONDARY EFFECTS OF THE COUNTERCURRENT

The secondary effects of the countercurrent were such as have been already described, except that in 1925 each successive phenomenon seemed to be enhanced. The plankton of the Humboldt Current succumbed, perhaps, as Allen suggests,[8] because *El Niño* carried some injurious chemical substance no less than because of its higher temperature. Local fisheries along the coast failed as the commoner schooling species died or departed. Flying fish, dolphins (*Cory-*

[8] W. E. Allen: Statistical Studies of Surface Catches of Marine Diatoms and Dinoflagellates Made by the Yacht *Ohio* in Tropical Waters in 1924, *Trans. Amer. Microscop. Soc.*, Vol. 44, 1925, pp. 24-30.

phaena), and other tropical fishes invaded the shore waters and even entered harbors. By the end of January sick and dead guano birds began to be numerous in northern Peru, and the *peste* spread rapidly southward until countless thousands of carcasses lined the whole shore line of the country. During early March the lighters at Callao and Salaverry, and doubtless in other Peruvian ports, were full of

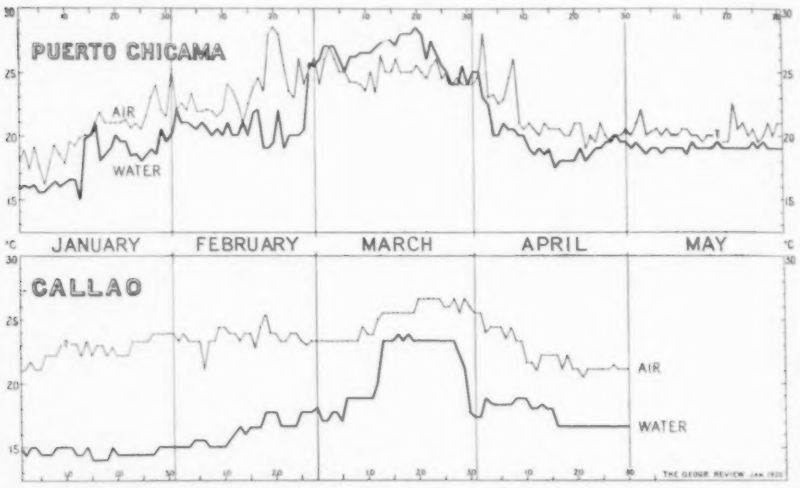

FIG. 2—Graphs to illustrate the abnormal temperature conditions during the earlier part of 1925 along the Peruvian coast. Observations for Puerto Chicama were taken at 8 a. m. Records for the observation hour of 4 p. m. and the daily maximum and minimum are available in the files of the American Geographical Society. These and other meteorological data were obtained through the kindness of Ambassador Poindexter.

emaciated, vermin-infested sea birds, which lacked strength to clamber over the high sides of the anchored craft.

Captain Dexter, in the appendix to Walcott's article in the July number of the *Geographical Review*, tells of the abandonment of the breeding grounds on the Lobos and Guañape Islands during March, and, in a manuscript report on his April–May voyage, he refers to the unwonted massing of Peruvian cormorants, boobies, and other guano-producing species in Chilean waters: "millions of cormorants fishing about the piers in Valparaiso"; "the Choros Islands, near Chañaral, and Alecrán Island, near Arica, covered with birds, with more forming broad stripes along the face of the famous Morro"; "birds resting on the mooring buoys in Chilean harbors to an extent never before observed"; etc.

A highly significant fact reported by observers in northern Peru is that the man-of-war birds (*Fregata magnificens*) were not affected by the *peste* which destroyed so many representatives of species endemic in the Humboldt Current. This is in accord with the tenets

of marine distribution, for the man-of-war bird is a tropical species, well adapted to ocean waters of high temperature, and apparently most at home in Peru during the incursions of *El Niño*. It is only during manifestations of the countercurrent, in fact, that the species seems to pass southward beyond the vicinity of Point Aguja.

Other birds characteristic of warm seas which were noted in Peruvian coastal waters south of their usual range in January, 1925, include a large intertropical booby (*Sula dactylatra*), and the red-billed tropic bird (*Phaëthon aethereus*). Moreover, several species of migrants from North America which ordinarily confine their wintering to the equatorial region, such as the laughing gull (*Larus atricilla*) and the royal tern (*Sterna maxima*), were observed south beyond Paita as soon as the countercurrent was well in progress.

Finally, a probable effect of countercurrent conditions upon the distribution of sea birds was the total absence off northern Peru during January, February, and early March, 1925, of certain subantarctic petrels (particularly the genera *Daption*, *Priocella*, *Procellaria*, and *Macronectes*), which the writer had found common during the same season of another year.

TABLE VIII—TEMPERATURES AT NEGRITOS AND TALARA, 1924–1925
(*Degrees Fahrenheit*)

	Negritos				Talara		
	Air		Water				
	Min.	Max.	Min.	Max.	Min.	Max.	Mean
1924							
J.	77	85	65	73	71	96	76
F.	80	90	65	72	75	95	81
M.	81	87	65	71	75	96	81
A.	67	83	61	68	70	96	78
M.	72	82	62	66	68	90	76
J.	68	74	60	66	60	83	67
J.	68	72	59	62	60	79	66
A.	66	71	60	64	60	79	65.5
S.	66	76	60	68	60	80	66
O.	71	78	62	68	60	80	67
N.	72	83	62	68	62	82	68.5
D.	76	88	63	70	66	87	71.5
1925							
J.	80	93	69	79	68	90	78
F.	74	94	68	81	75	93	82
M.	76	90	72	82	76	93	83
A.	80	90	71	82	76	94	83
*M.	79	87	70	74	75	93	81

*May 1–23 only.

THE RELATIONS OF TEMPERATURE AND THE RAINS

Southerly breezes noted off Talara and Point Pariñas on January 19 and 20, after the incipience of the countercurrent in this latitude, were probably the last sustained winds from this direction for many weeks. Thereafter, in both northern Peru and on the outer coast of Ecuador the observed circulation proceeded mostly from a northerly quarter with occasional reversals of a few hours' duration. Reports from the long coast of Peru to southward indicate that similar conditions and phenomena prevailed there.

FIG. 3.—Hacienda Soho near Piura before the heavy rains (compare the rainfall records, pp. 38, 39, 42).

Small differences in ocean temperatures are likely to cause great changes in barometric pressures. A critical study of the few available records of air and surface water from northern Peru shows that the change in weather, including the rain, came at the time when the temperature of the ocean began to equal or exceed the mean temperature of the atmosphere and that the exceptional rainfall continued just so long as this altered ratio was maintained.

One of the factors of meteorological stability on the arid west coast of South America is that the mean temperature of the surface water close to shore is normally not only lower than that of the outlying Pacific, but is also decidedly lower than that prevailing over the adjacent land. The relationship holds good for northern Peru, at least as far as Cape Blanco, as well as for the central part of the coast. The absolute maximum and minimum temperatures of both air and water taken daily at noon at Negritos near Point Pariñas during 1924, the first year in which such observations were made, well illustrate this normal ratio (Table VIII). The average temperatures of the air for every month of 1924 are markedly higher than those of the water, and in only the two months of April and September does the absolute minimum temperature of the air fail to exceed the maximum temperature of the water for the same period.

From the same data it may be noted that in 1924 the highest water temperature of the entire year was 73° F., reached only once (January 27). Water temperatures of 70° F. or more were recorded, indeed, on only fourteen days during the year, these occurring in January, February, March, and December.

Similar data for the first four months and twenty-three days of 1925, show how greatly conditions departed from the normal during the season under consideration. Not only is a difference of close to 10° F. revealed in the average maximum temperatures of the water for the comparable periods, but, moreover, the ordinary ratio between

FIG. 4—Hacienda Soho. Floods after the heavy rains (compare Fig. 3).

air and water temperature is seen to have been disturbed during the critical months of February, March, and April, 1925.[9] Data for Talara show similar abnormally high temperature of the air during March, April, and May.

THE PHENOMENA OF 1891

For two weeks preceding the appearance of the rains at Talara and Negritos in 1925 increasing masses of dark clouds hung above the Amotape Mountains some fifteen or more miles inland. Old residents remarked that there had not been so threatening a prospect since the season of 1891, and predictions were freely made of an approaching deluge. Events of 1925 did, in fact, follow so closely the pattern of the period thirty-four years earlier that it will be of interest to quote two unpublished accounts of the latter by eyewitnesses. The first, from the files of the International Petroleum Company at Talara, was written by Mr. H. Tweddle, of Lima, in January, 1922. It refers to the weather conditions of thirty-one years before and demonstrates how vividly they were remembered.

> The periodic rains in Talara and the adjoining country . . . are by no means regular. Formerly they were supposed to occur every seven or eight years and were known as "years of abundance," since the desert soil is soaked by the heavy downpour, and within a few weeks the whole country is covered with abundant pasture. The natural increase of flocks is practically doubled, and cotton can be grown in places where in other years vegetation seems impossible.
>
> . . . The most reasonable explanation of these rains is that they have something to do with the *Corriente del Niño*, or Reverse Humboldt Current. Prac-

[9] All data from daily records made by Messrs. Stauft and Olsson, of the International Petroleum Co., Ltd. at Negritos.

For further illustration of the normal temperature relations see an important tabulation covering two complete years at the Lobos, Guañape, and Chincha Islands, Peru, in J. A. de Lavalle: Datos para el estudio de la relación entre las épocas de realización de las principales faces de la vida de las aves y las condiciones climatéricas. *Memoria de la Compañia Administradora del Guano*, Vol. II, 1920, pp. 77–168.

tically every year in January, February, and March, you get very hot days with a light wind, and sometimes the *Corriente del Niño* appears and runs as far south as Chimbote; its presence is often marked by the appearance of yellow-bellied water snakes, many of which are cast up on the beach dead or dying. . . .

The last rains were in February, 1891, . . . and they were certainly torrential. We could see the heavy black clouds gradually approaching from the northeast a fortnight before they actually broke, and the rain that ensued was the heaviest I ever saw. It seemed to come down in sheets, like a cloudburst, but was by no means local in character. . . .

At Talara the first rain, which came during the night, flooded the flat plain and broke through the raised beach. . . . The whole plain was inundated with water two or three feet deep and became a quicksand. . .

I quite understand that people think I exaggerate matters, since the country is so dry and parched, but the rains of 1891 were so great that a river was opened up on the east side of Talara Bay and we sounded it over 50 feet deep. . . .

The writer of the letter goes on to say that a survey made by the officers of H. M. S. *Garnett* toward the end of 1891, when the river referred to had silted up considerably, still showed a depth of 7 fathoms at its mouth, which was then 500 feet in width. He concludes with timely instructions relating to the protection of the oil company's property in the event of a recurrence of the floods.

The second letter, which follows, was written in April, 1925, by Mr. S. M. Scott, of Florence, Italy, and is quoted through the kindness of Mr. E. P. Mathewson, of New York.

Many thanks for your Peruvian cutting. It didn't surprise me at all, for it chances that I was there during the rains 34 years ago. . . .

This change of the current and its accompanying rains has a normal periodicity of seven years, and anyone familiar with that coast and its hinterland must have observed that the scoring of the cliffs and the gullying of the *tablazo* [near Talara] were caused by torrential rains in very recent times. But there is other testimony far more reliable; when we took over the hacienda it was already celebrated for its cotton. The surface of the *tablazo* is of course irregular and abounds in depressions of considerable extent. In these the rains gather and form ponds or lakes. The sand, which seems to cover what during the dry season is a desert, is mingled with and overlies great areas of volcanic dust which is extremely fertile when irrigated. At no great distance below the surface is an impenetrable stratum of clay upon which the rain water eventually settles. Immediately after the rains these lakes are assigned to peons who are obliged to plant cotton in the mud as the water recedes and who are permitted to grow pumpkins and other garden truck between the rows for their own account. Once below the surface, the water sinks very slowly and the roots of the cotton plant are able to follow it down for sometimes as long as three years, after which, of course, the plant dies. This practice prevailed in all the haciendas of the Province of Piura, and in my time it was declared that the sabbatical rains had failed only once within living memory. . . .

A low-hanging, densely clouded sky, intense heat, great humidity and an oily sea—so it began. The temperature varied little during the twenty-four hours. Everything we possessed became mildewed. The rain fell in inconceivable torrents for weeks, but chiefly at night, rarely in the day time. After dark the sea broke in phosphorescent lightenings all along the coast. During the day it was covered with blood-like patches many acres in extent caused by minute organisms—whether animal or vegetable I cannot say. . . .

Hammer-headed sharks were always to be seen at the mouth of our bay and along the coast, therefore the great school Murphy describes was probably of local origin, drawn together by the warm current. Our boat was, however, frequently followed by huge man-eating sharks such as one usually sees only about Panama. In addition to innumerable kinds of fish large and small, the current carried great quantities of long yellow and black water snakes. My boy killed one of these, some six feet long, under the writing desk in my bedroom. Now as my house was on the side of the steep cliff, about 200 feet above sea level, you may be able to tell me how the beast got there. One afternoon riding along the beach I flushed a fair-sized alligator which hoisted its tail and dashed into the sea, not a bit more surprised than I was. The brute may have been washed out of the Chira, about the lower reaches of which his tribe flourishes, but as I came upon him far north of that river, and as it isn't likely he could have made head against the strong ocean current, I am of opinion he drifted down from Guayaquil.

If the sea was full of wonders the land was even more so. First of all the desert became a garden. . . . Almost every evening we were pestered by swarms of insects, of ever-changing variety and of every size and shape imaginable, that dashed themselves against the lamps and had constantly to be brushed off the table. I remember one delightful creature in particular, beetle-like and of a metally green hue, that ran like lightning over the dinner table and impregnated everything it touched with the odor of iodoform. The way in which these insects succeeded one another was probably due to the unequal development of the different plants and flowers on which they lived. Even more remarkable perhaps was the great variety of spiders that came into the house, dozens of species we had never seen before and never saw afterward; as spiders don't fly it was difficult to account for their presence.

In the lakes and ponds of which I have spoken, weeds of many kinds grew rapidly. These attracted flocks of strange-looking wild ducks that must have flown down from the Guayaquil region in order to feed upon them. . . .

When the grass on the desert eventually withered it formed a natural hay, affording pasturage to the goats for a year or two. It is also remarkable that during the wet season there was rarely any wind; the sea had a lifeless, uncanny look and we never saw the sun.

When I went to Talara just before the rains the Chira was a goodly stream, unfordable, flowing close to the cliffs on the southern side of the valley. The important town of Amotape was built on a raised shelf on the northern side. Between the town and the river was a level plain highly cultivated by irrigation, with farms, gardens, banana orchards, and the like, and a particularly beautiful grove of old algarroba trees, prized as you know for their bean-like fruit or seed pods which take the place of oats as food for mules and horses. The river must have previously kept to the southern channel for many a long year, as the trees in the grove were exceptionally large and the species is of slow growth. When I visited Amotape shortly after the rains had ceased, I found that the orchards and gardens and the beautiful old grove of trees had all been swept away. The river in subsiding had cut an entirely new channel for itself and now flowed just below the town. I think at that point the valley must be nearly a mile wide, so you can picture to yourself the quantity of water that must have flowed through it and the havoc it wrought. I am sorry to say I do not remember how long the rains lasted.

Rains and Temperatures of 1925 at Talara and Piura

The following parallel columns comprise a journal of the rainfall in northern Peru. The Talara data were recorded in the offices of the

International Petroleum Company, Ltd.; those for Piura by the municipality of that city. For both records the writer is indebted to his friend Mr. L. M. Stone, Mayor of the District of Máncora, of which Talara is the capital.

	TALARA	PIURA
January		
19.	Fitful spatter of rain in evening, after wind had switched to east of north.	
27.	Raining hard at daybreak and till 10 a. m.; northerly wind. Again from sunset till 3 a. m. of Jan. 28.	
February		
2.	Hard rain all night till 6 a. m. of Feb. 3.	
4.	Rain all night till 5 a. m. of Feb. 5. On the 5th the ravines full of water; communication with Negritos suspended.	The first heavy shower, from 5 till 5:30 p. m.
7.		Heavy rain all night.
12.	Hard rain all night and till noon	Hard, steady rain from 8 to 11 p. m.,
13.	of Feb. 13. Streets impassable. Deep quebrada of the Pozo flooded. Two men reported drowned in Negritos.	then moderate till midnight. Heavy rain from 8 to 12 p. m. on Feb. 13.
15.	Moderate rain for half an hour during the night.	First electric storm began 10:30 p. m. and continued all night. At midnight a clap of thunder at an interval of five seconds after the lightning.
16.		Raining at dawn and continued intermittently till noon.
19.		Heavy rain from 4 to 6 p. m., followed by drizzle (*garua*); another heavy fall from 10:30 p. m. till midnight, with a very severe thunderstorm.
20.		Very heavy rain from 4:15 to 5:30 p. m.
23.	Heavy and light rain intermittently from 1 a. m. till 10 a. m. Highways impassable; all routes to river closed.	Moderately heavy rain from 3 to 4 p. m. Heavy rain after 6 p. m. At 8 p. m. the river attained depth of 6.3 meters and began to flood the city.
24.	Much north wind; rain for an hour after 5 p. m.	
26.	Hard rain during night for about two hours.	
27.	Rain during night for an hour and a quarter.	Heavy rain from 11:30 p. m. till daybreak of Feb. 28.
28.		Heavy rain from 11 p. m. till daybreak of Mar. 1.
March		
2.	Intermittent rain through night and till 11 a. m. of Mar. 3.	Heavy rain from 10 to 12 p. m.; thunder and lightning.

	Talara (continued)	Piura (continued)
March		
5.	About two hours' rain during night.	Heavy rain from 3 to 3:30 p. m.
6.	Heavy and steady rain for an hour.	Steady, hard rain from 8 a. m. to 12:30 p. m.
8.	Heavy rain for an hour after 10 p. m., followed by drizzle (*garua*).	Steady, hard rain from 10 to 11 p. m.
9.	Drizzle from 7 to 9 a. m.	Heavy rain from 9 to 11 p. m. when torrential downpour for 15 minutes. Afterwards moderate rain till 11 a. m. of Mar. 10.
10.	Rain for hour and a half; north wind; much thunder and lightning about Cerro Prieto.	
11.		Moderately heavy rain from 6 to 7 a. m. From 4 p. m. rain till midnight with greatest intensity between 9 and 10 p. m.
12.	Gentle drizzle from before midnight till 4 a. m. of Mar. 13.	Steady, heavy rain from 7 to 12 p. m.
13.		Heavy shower for 10 minutes at 3 p. m Light rain beginning 10 p. m. followed by heavy downpour from 1:30 to 2 a. m. of Mar. 14.
15.	Violent rain with north wind for hour and a half after 9 p. m.	Heavy rain from 6 to 9 a. m.
16.		Light rain from 3 to 6 a. m. and moderately heavy from 12:15 to 5 p. m.
18.	Heavy downpour from 3 till 7 p. m.	Fall of large drops for about 5 minutes at 1 p. m.
19.	Rain from 3 till 11 a. m.	At daybreak river rose to unprecedented height of 6.7 meters, remaining there all day.
21.		Moderately heavy shower of 10 minutes at 4 p. m.
23.	Violent rainstorm, thunder and lightning, for hour during night.	Moderately heavy rain 3 to 4 p. m.
24.	Showers from 10:30 a. m. till noon. At 1:30 p. m. tempest with much thunder and lightning between Talara and Verdun, till 3:30 p. m. At 10 p. m. heavy rain again till dawn of Mar. 25, with northerly and westerly winds. Tunnel to Negritos completely obstructed.	
26.	Rain, with much lightning but no thunder, beginning at 8 p. m. At 10 p. m. five-minute squall, with very large raindrops, filled streets with water. Afterwards gentle rain all night till 8:30 a. m. of Mar. 27.	Heavy rain from 3:15 to 4 p. m., continuing moderately till 5 p. m. From 5 to 6 p. m. furious thunderstorm. At 5:15, after vivid flash of lightning, clap of thunder after interval of three seconds.

FIG. 5

FIG. 6

FIG. 7

FIGS. 5, 6, 7—Floods and flood damage in the neighborhood of Trujillo. Figure 6 shows the invasion of a cemetery. In Figure 7 is seen pasture land ruined by the floods. (Photographs from Major Holstein.)

FIG. 8

FIG. 9

FIG. 10

FIGS. 8, 9, 10—Effect of the rains in Trujillo. Figure 10 shows the expedient adopted by the railway between Trujillo and Salaverry for ferrying passengers across the Moche. In ordinary times this stream can be forded on foot. (Photographs from Major Holstein.)

Talara (continued)	Piura (continued)
March	
27. North wind; at 10 p. m. heavy downpour for two minutes, followed by drizzle for an hour.	Light rain from 1:30 p. m. till midnight.
28.	Moderately heavy rain from 10:15 till 11:30 p. m., then torrential for 10 minutes. Moderate afterwards till 3 a. m. of Mar. 29.
29. Heavy rain, with north wind, from 5:30 to 11:30 p. m.	Steady, heavy rain from 2 to 2:30 p. m. Intermittent from 4:45 to 10:30 p. m., torrential downpour for 15 minutes; sporadic showers till 2 a. m. of Mar. 30.
30. Rain for half an hour after 3:30 p. m., and again from 8 to 11 p. m.	Steady, heavy rainfall from 4:30 to 6 p. m.; intermittent rain from 8:30 to 9:15 p. m., then exceptionally torrential downpour for 2¼ hours. Afterwards light drizzle.
31.	Furious thunderstorm from 1:15 to 10:30 p. m. Average intervals between the flashes, 30 seconds. Light drizzle till midnight.
April	
1. Drizzling rain, with north wind, began 5 p. m. Thunder heard toward Pariñas Valley. Rainbows about 6 p. m. Heavy drizzle till 7, and more rain, with lightning and thunder, from 8 p. m. till 2 a. m. of Apr. 2.	According to the rain gauge, 327 liters of water per square meter have fallen in Piura between Mar. 7 and Apr. 1.
2. Five minutes' drizzle at 5:30 p. m. Steady rain, with lightning and thunder toward Cerro Prieto, from 9 p. m. till 3 a. m. of Apr. 3.	
3. Drizzle for a half hour after 11 a. m. Rain for 15 minutes after 5:30 p. m., with a north wind.	
4. Drizzle from before midnight till morning of Apr. 5.	
6. Gentle rain from 2 to 4 a. m.	
8. Complete change of weather evident.	
9. Very strong south wind from midnight till 11 a. m. of Apr. 10.	
16. Recurrent rains from 5 to 7 p. m. After 8 p. m. light but steady rain till dawn.	
18. Slight drizzle for half an hour.	
19. Drizzle, changing to rain, during evening and till dawn.	
26. Little rain at daybreak and again in the evening.	
June	
4. Very slight rain in early morning.	

A broader description of the meteorological and oceanic changes in the neighborhood of Trujillo, latitude 8° 7′ S., which began from a month to five weeks later than at Point Pariñas, is contained in the following letter to the director of the American Geographical Society from Major Otto Holstein. It is dated Trujillo, May 19, 1925.[10]

During the early days of March past a notable increase in the temperature became apparent, followed on March 7 (at Trujillo) by the commencement of a series of

FIG. 11

FIG. 12

FIGS. 11, 12—Damage done in Trujillo post office by the rains. The photograph on the left shows the result of running water on the base of the adobe walls. (Photographs from Major Holstein.)

intermittent rains that lasted throughout the remainder of March and for the first few days of April.

Coincident with the increased atmospheric temperature, a great increase in the temperature of the sea was noted; the latter rose from an average of 60° F., in normal times, to a temperature of 75° F. . . . Ships at anchor in unprotected roadsteads along the Peruvian coast swung to their anchor-chains with their bows pointing to the north instead of the south, indicating a new condition of affairs, namely that the current was flowing from north to south instead of in the normal south-to-north direction. It was plain that the warm equatorial current, or, as it is known locally, *El Corriente del Niño*, had come down from the north. . . .

On March 1st last the temperature rose to 36.0° C. (97° F.). The mean maximum for the month was 32.6° C. (91° F.). The rainfall of Trujillo is so slight that it may almost be said to be non-existent. The "rains" occurring between 1918 and 1925, as recorded by the most modern apparatus are shown in Table IX. The total for

[10] See also extracts from a letter of April 5 published in the Appendix to Walcott's paper, footnote 5.

this seven year period was 35 millimeters; for March, 1925, it amounted to 395 millimeters.

The atmospheric pressure as noted by the barometer at the local meteorological station from March 1st to 4th inclusive, corresponded to that of preceding years, but on the 5th there was a fall of 4 millimeters, which was all the more marked since it occurred in the interim between 11.00 a. m. and 4.00 p. m. From March 7th the barometer commenced to rise slowly but always remained below the average for the same period of previous years. This condition obtained until March 14th, after which date no further barometrical data are obtainable since the apparatus was destroyed by the caving-in of the roof of the building.

TABLE IX—RAINFALL AT TRUJILLO MARCH, 1925

Day	Rain in MM.
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0
6	0.0
7	226.0
8	
9	
10	2.0
11	41.0
12	0.5
13	9.0
14	22.3
15	16.5
16	18.5
17	0.0
18	6.2
19	2.0
20	1.3
21	6.2
22	0.0
23	0.0
24	28.9
25	0.0
26	0.0
27	1.5
28	1.0
29	9.0
30	2.5
31	0.0
Total	394.4

It was noted that on the days of greatest precipitation the winds were E., N. E., N., N. N. W., N. W., and that the velocity during the 24 hours was from 18 to 33 kilometers. On the days of least rainfall the prevailing winds were E., S. E., S. S. E., S. S. W. and W. S. S., the velocity being between 30 and 35 kilometers. On the days during which there was no rainfall the winds were S. S. W., and their velocity from 15 to 34 kilometers. The normal winds for the like period of preceding years were S. S. W. and S. W., and their velocity from 180 to 300 kilometers for 24 hours, the greatest wind velocities being recorded between the hours of 12 noon and 4 p. m.

From March 1st to 6th the humidity was approximately 76 per cent and was very high during the remainder of March, varying between 87 and 100 per cent.

Evaporation during March of previous years averaged 3 mm., while for March, 1925, it amounted to 7 mm. During the days when it rained the evaporation varied between 0 and 1 mm.

Great damage was caused all along the coast by washing out roads, railways, bridges, and other structures; some houses were, it is true, destroyed by flood waters, and all the rivers and dry quebradas became raging torrents. At one point not far distant from Trujillo it was possible to watch the purplish-black clouds being carried from the sea to some near-by peaks and see them precipitated there in the form of cloudbursts and a short time thereafter see the hitherto dry quebrada with a solid wall of water approaching, carrying everything before it. The towns, villages, and settlements are, for the greater part, built on higher ground, and, although there was always the threat of a flood, it fortunately did not occur in Trujillo where the greatest damage ensued from walls and ceilings as well as foundations having become thoroughly water soaked, causing them to disintegrate in much the same manner as a lump of sugar does when placed in liquid. . . .

Very soon after April 1 a cool, fresh feeling was apparent in the sea breeze, and it was noted that the ocean temperature was again normal; and since then matters have continued reëstablishing themselves until at the present writing normal conditions again obtain.

The so-called "wet" season of the Coast Range seems to have been particularly well developed during the winter. Not only was

the usual *garua* (mist) experienced in the hills, but rain actually fell in the ports. A letter from Mr. S. K. Lothrop of the Museum of the American Indian, Heye Foundation, reports hard rain at Antofagasta on June 26; drizzle on succeeding days at Mollendo, Ilo, and Pisco; drizzle and rains and "a surprisingly brilliant green of the hills" in the country between Lima and Pisco in the first fortnight of July.

TABLE X—RAINFALL AT TRUJILLO, 1918–1925
(*In Millimeters*)

1918—June	15	0.2	
1919—Jan.	17	2.0	
Feb.	4	6.9	
"	5	1.9	
Oct.	10	3.0	
"	15	1.0	
"	16	1.0	
Nov.	14	1.0	
1920—Mar.	17	1.3	
1921—Aug.	21	0.3	
Sept.	29	0.9	
1922—Dec.	16	1.0	
"	17	0.8	
1923—Feb.	19	0.8	
"	26	1.0	
"	27	1.0	
Mar.	9	0.5	
Dec.	14	8.3	
1924—Sept.	15	2.0	
Total for period			34 9

A letter from Mr. Stone received in October says that until the middle of September it still rained slightly at night in Talara. Major Holstein reports the continuation of abnormally high temperatures at Trujillo through the winter and expresses a general belief that further trouble is to be anticipated. He sends records of maximum and minimum temperatures at Trujillo for 1924 and 1925. The records are incomplete, especially for 1924, but reduction to monthly means indicates clearly enough the trend. Temperature in degrees Centigrade.

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.
1924	26	26	26	25	23	21	20.5	19	20	20.5
1925	26	28.5	29	27	26	25	22.5	22.5	23	23

PROGRESS AND SEQUELAE OF THE FLOODS

Serious effects of the rains, due to the overflowing of natural drainage channels, seem to have occurred simultaneously over wide areas in the highlands of the Pacific slope before there was appreciable precipitation on the coast. In what is ordinarily the most cloudless region of Chile continuous wet weather for over a month made solar observations impossible during January.

The Harvard Observatory at Carmen Alto reported the heaviest rainfall for the Arequipa district since February, 1893. The average yearly precipitation at Arequipa is about 100 mm. (4 in.), but between January 22 and 31, 1925, 132 mm. (5.18 in.) were recorded, of which 32.5 mm. fell on January 27 alone. We may compare the figure of 327 mm. at Piura between March 7 and April 1.

Beginning about January 23 swollen mountain torrents flooded much territory along the Southern Railway of Peru and cut the line itself at thirteen different points between Arequipa and Yura, on the route toward Cuzco, incidentally depriving Arequipa of electricity. Much damage was done also in many other places, from the Oroya Railroad, which crosses the Andes from Callao, southward into Tarapacá.

In February, despite continued rains, much emergency reconstruction was undertaken, but about the end of the first week in March conditions in the mountains of central Peru became worse than ever, and at the same time the rainfall at sea level worked southward to the valley of Chicama (compare Major Holstein's report) and to Casma. On March 24, according to Peruvian newspapers, 95,000 metric tons of water fell upon Trujillo. Tens of kilometers of track of the Central Railway, together with many of the bridges, were carried away; and on March 18 Lima and Callao were left without light and power, owing to the destruction of the hydro-electric stations at Chosica and Yanacoto.

For more than three months thereafter communication between Lima and the hinterland was uncertain and precarious, and the food situation soon became acute. Fortunately, primitive transportation systems were ready to resume their former rôles. Mules, burros, and llamas largely replaced the railroad in carrying potatoes, onions, eggs, and other supplies from the sierra to the coast. Chosica (altitude 2800 feet), where ordinarily not six, perhaps not two, llamas might be seen during the course of a year, now became the rendezvous of as many as eight hundred in a single day. Mutton on the hoof was also driven down to the great population centers, one flock of six hundred sheep journeying into Lima from the lofty grasslands east of Cerro de Pasco.

The Rimac rose to within eighteen inches of the embankments and arches in Lima, driving hordes of rats into other parts of the city. In the valley above the capital, as well as in the Ica valley to southward and in numerous agricultural river basins of northern Peru, great injury was done through the sweeping away of cotton and other plantations and of the none too plentiful beds of arable soil.

Mr. C. W. Sutton, in charge of the government's vast irrigation project in the Olmos section of the northern coast, wrote on April 16:

> Lambayeque was the town most menaced by the floods—in fact it is in the bottom of a natural reservoir and could only be defended by building dikes about it high enough to top the rising water. On March 12—from that same church tower from which we had seen orchards and palms bordering a desert—one could see naught but water, with here and there a dune, or the roof of a house sticking above the surface, or a group of trees standing as if on an atoll.

From March 12 to 20 we ran the floods a race—trying to build the dikes to the needed height before the water rose above them. We gained by an inch on March 20—a bare inch—and then the water began to subside.

In the Talara district the March floods wrought enormous damage to buildings, machinery, roads, tracks, telephone lines, pipes, etc., finally carrying away the costly and elaborate pumping station of the International Petroleum Company at Vichayal, on the Chira River, so that part of the fresh water for a population of more than 12,000 had to be transported by tank steamer from Callao, 550 miles away.

The following comments are freely transcribed from several letters to the writer from Mr. L. M. Stone. They are dated at Talara, April 9 to August 17, 1925.

We have felt excessive heat; abnormal stillness of the atmosphere, not experienced before the rains nor after their termination; intense humidity. . . .

Recently I had occasion to journey from Paita to Piura along the partially repaired railroad. On the way, I was struck by the great extension of the lakes which, of course, are wonderful breeding grounds for mosquitoes. Malaria is now rife in Catacaos and also in the Chira River towns. Rheumatic complaints are common, and it is asserted that *dengue*, or breakbone fever, has appeared at Paita. Beriberi, too, has claimed many victims because of the shortage of vegetables. Market gardening has been undertaken wherever the nature of the ground has offered opportunity. The *tablazo* at Paita, for instance, has been sown by seekers of quick crops, but night frosts have affected some of these very adversely. In Trujillo, property values have fallen greatly, not only on account of the damage suffered but also because the inhabitants fear that the rains may repeat every year.

The lack of proper food has undoubtedly sent up the death rate alarmingly. In Piura, with about 10,000 inhabitants, there were 175 deaths during April as against 347 for the entire year 1924. Of the April deaths 117 were among children under five years of age, 66 of these being due to gasteroenteritis.

The local papers have compiled the following statistics to show the rapid increase in death rate during the progress of all seasons marked by heavy rainfall:

	1878	1884	1891	1925
Jan.	48	13	17	37
Feb.	52	20	35	39
Mar.	64	42	52	94
Apr.	35	60	45	175
May	38	53	44	
June	19	41	19	

The rains have given growth to abundant vegetation about Talara, especially in the quebradas. Later it should be a bumper year for cotton. Young algarroba and alfalfa plants are now common, springing up mostly from the droppings of horses and burros. Watermelons with fair-sized fruit are sometimes found. At Máncora vegetation is particularly luxuriant, the grass on the *tablazo* standing three feet high on May 26. In Piura I was impressed by the quaintness of the soaked thatched roofs, which looked as though roof gardens were being cultivated. The principal plant was the suravía, which has a white, bell-shaped flower.

In April we had millions of dragon flies, known as *caballitos del diablo*, which were reputed to feed upon the mosquitoes. With the winter winds and sand storms of June the *grillos*, or crickets, arrived in hordes and feasted upon the vegetation.

With reference to the rapid development of malaria in the Talara-Negritos communities after the rains, Dr. A. W. Schoenleber, of Montclair, N. J., has given the writer further data. The normal rate in this region is less than two per thousand, as compared, for example, with a recent annual rate of about 19 per thousand at Panama. But for the month of July, 1925, the rate for Talara and Negritos, on an annual basis, stood at 140 per thousand. Beriberi, which, because of the food habits of the native inhabitants and the relative scarcity of green stuffs for the large population of the petroleum centers, is always a threat, likewise increased with the commissary difficulties. Within four weeks after the towns had been cut off from ready communication with the agricultural river valleys the physicians were seeing from thirty to forty new cases per day.

According to the director of the National Guano Administration the March deluges washed 35,000 tons of guano into the sea, chiefly from the Lobos, Macabí, and Guañape islands. Even more disastrous than this immediate loss of a natural resource was the inevitable diminution of nitrogen content and therefore of fertilizing efficacy, through the extensive absorption of water by the guano deposits. Most serious of all, however, was the death of adult guano birds through disease, at the height of the breeding period, and the abandonment of countless thousands of nests containing eggs or young.[11] This is likely to lead to a scarcity of the indispensable fertilizer during future years.

The higher temperature, and perhaps the altered salinity, of the ocean water apparently had the effect of greatly increasing the fouling of ships' bottoms. An inkling of the increase of fresh water poured into the Pacific from engorged streams may be gained from the flow of the river Piura, which is usually dry during the greater part of the year (Fig. 15). At the time of maximum elevation, this river must have discharged at the rate of 70 million cubic meters every twenty-four hours, or practically one-tenth of the normal annual outflow of such perennial streams as the Rimac and the Pisco.

The addition of so much flood water had a marked effect upon the salinity of the coastal ocean. Thus hydrometer readings of samples taken at the surface by Mr. Heilner and the writer on January 28, between Cape Blanco and the Túmbez River, showed densities of 1.0247 when corrected for instrumental errors and reduced to a value of 15° C. Three readings taken along the same part of the coast on March 4 showed considerably lower densities, viz. 1.0211 off Zorritos, 1.0213 off Punta Sal, and 1.0180 off Máncora Cove.

When the writer traveled by launch from Guayaquil to Talara, and then to Paita, on March 3–6, 1925, the first climax of the new meteoro-

[11] F. Ballén and J. C. Gastiaburú: La emigración y mortalidad de las aves en el verano de 1925, *Memoria de la Compañia Administradora del Guano*, Vol. 16, 1925, pp. 41–45.

FIG. 13

FIG. 14

FIG. 13—The "head" of El Muerto (Santa Clara) Island, Gulf of Guayaquil, showing knife-edge erosion of loess beds during the rains of February, 1925.

FIG. 14—La Plata Island (see Fig. 16), showing cacti and other xerophilous vegetation in the background and rain vegetation on the coastal terrace. The conspicuous white blossoms are spider lilies (*Hymenocallis*). February 18, 1925.

logical régime had already had time to produce many strange effects. Lightning played constantly along the Peruvian coast north of Zorritos throughout the night of the third. At daybreak of March 4 the "desert" shore presented a remarkably different aspect from that of five weeks earlier, for it looked almost as green as a landscape of the humid zone. The area of richest vegetation terminated abruptly, however, at the southern border of the valley of the Máncora River. To southward the high *tablazo* which stretches toward Cape Blanco was blessed with a few shrubs and stunted trees, but the weathered seaward face of this part of the coast seemed to be practically bare of plant growth.

The post-fluvial, more or less ephemeral, vegetation which sprang up at many points along the Peruvian coast after drought periods ranging up to at least 34 years in length offers an interesting subject for investigation. The writer has no knowledge of these plants and made no collections, but several capable botanists were fortunately in the field at the right period. As indicating the rich variety of vegetation of this type, Dr. Frank M. Chapman, of the American Museum of Natural History, has kindly transmitted the following passage from his notes:

> Mollendo, December 8, 1918. As a result of 76 hours' continuous rain, flowers are abundant on the pampa and, it is said, "for the first time in 40 years" flowering plants have reached the seacoast. I counted 20-odd species, nearly all in flower, though the season of bloom appears to have passed its prime and many plants have matured their seeds, which may have to wait 40 years more for their turn. The foothills are much greener than the pampa, a decided green—not greenish.
>
> December 9, 1918. Along the railway line to Arequipa, immediately south of Mollendo, flowering plants were growing in masses to the surf line, with among them many which were dry and withered. This growth increased in richness up to Km. 50 (about 1800 feet altitude), where it was lush and luxuriant; then it suddenly ceased.

For many miles along the coast of northernmost Peru, during the March journey from Guayaquil southward, the writer's launch passed through belts of murky, yellowish-green water in which floated quantities of logs, branches, leaves, and other valley débris. Here and there a sharp line of congested flotsam divided such areas from clear blue water. When the launch passed from one to the other the leaping and darting of small fishes and other creatures in the concentrated rubbish told of the abundance of life along such boundaries. Contrary to expectations, the temperatures proved to be nearly the same in areas of both types, nor were the densities more than very slightly dissimilar.

Talara, on March 5, was a morass, despite a system of ditches which had been constructed to drain the flats from the base of the *tablazo;* and the heaviest rains were still to come. Swimming in the streets were great numbers of young mullets, identified from specimens as *Mugil*

thoburni, which had in some manner worked up from the ocean during the course of the floods.

The harbor had frequently been choked with countercurrent flotsam in which the bodies of birds, fishes, and other creatures were mingled with vegetation from northern quebradas. Live reptiles had also floated ashore on rafts of green plants. Among specimens which had been preserved in anticipation of the writer's return were a venomous serpent locally known as a *macanche* (*Lachesis lanceolatus*) and an Ameiva-like lizard (*Dicrodon lentiginosus*). The latter has not pre-

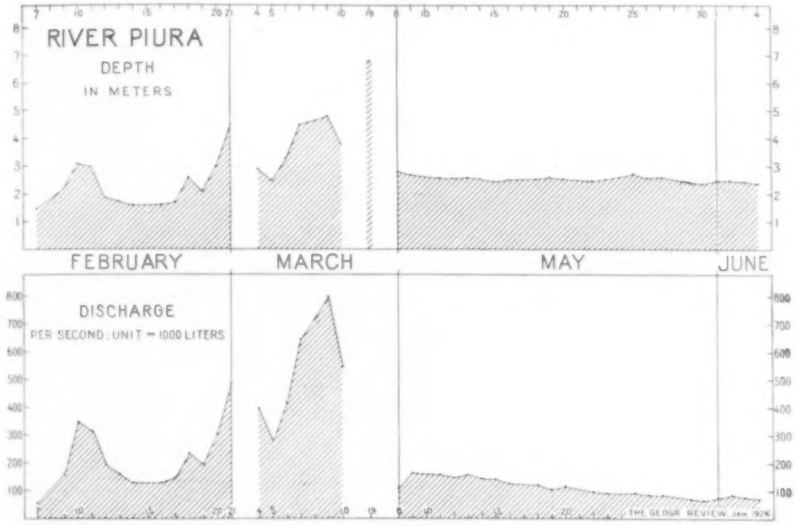

FIG. 15—Discharge and depth of water in the Piura River during the floods of 1925. On March 19 the observation point was swept away, and records could not be resumed until May 8. Compare the normal regimen shown in Figure 69 of Bowman's "Andes of Southern Peru."

viously been recorded from Peru, though it is abundant on El Muerto (Santa Clara) Island in the Gulf of Guayaquil. It is exceedingly interesting from a zoögeographic point of view that the species of lizard and snake found alive on flotsam in northern Peru should be similar to, or identical with, species supposed to have been transported by natural rafts to certain islands of the Lesser Antilles. Martinique, for example, is cursed by the presence of the *fer-de-lance*, the same snake as the one taken from stranded vegetation at Talara.

At this date the vultures were in clover, for carcasses dotted the shore line. Pockets of water lay here and there on the back-beach slope, and straight-walled gulches, twenty feet or more in depth, cut it in various directions. One new river was said to contain water seventeen feet in depth. The cemetery had fared dismally, for crosses and headstones had toppled by the score and coffins had been flushed from the graves.

The edges of the *tablazo* showed the result of rainfall erosion at its best, for the surface soil had here been carried away, leaving huge knobs of sandy conglomerate standing upon mushroom-like stems. The plateau was soft from more rain water than it could readily absorb, and the pebbles and shells of the old, uplifted sea floor had been washed clean.

The distant Amotapes were black—deluged at the moment with rain and bursting into flame with long flashes of lightning. To many inhabitants of this region lightning and thunder had come as unknown and terrible phenomena.

On the evening of March 5, the writer reëmbarked for Paita, passing en route through an endless series of drift lines composed chiefly of finely comminuted flotsam but with here and there a bole or bough from territory north of the desert. Some time after two o'clock in the morning of the 6th rain began to fall, and at daybreak the harbor and town of Paita presented a forlorn and untoward appearance. Hard, steady rain was pelting down before a northwest wind. A broad stream of muddy water gushed out between buildings along the water front, and a deep arroyo occupied the site of one of the principal streets. Above, at the edge of the mesa, huge oil tanks were tilted at dangerous angles, as the falling water undermined their foundations.

Conditions in Western Ecuador

The rainy season in Peru was contemporaneous with weather of the same type along the semiarid coasts of Ecuador. Although the inner shores of the Gulf of Guayaquil, including the island of Puná and the valley of the Guayas River are subject to an annual rainy season, the lower part of the Gulf and the coast from Point Santa Elena north to Cape San Lorenzo are regions of scanty precipitation. The dividing line between the territory of annual rains and that of rains at intervals of several years runs northward through the delta of the Túmbez River, passing to the eastward of El Muerto (Santa Clara) Island, across the base of the peninsula of Santa Elena, and thence northward not far from the shore. The country on the western side of this line is covered with a xerophytic type of vegetation, very poor in variety and luxuriance on El Muerto and at Santa Elena but becoming richer toward the north. La Plata Island, for example, has a varied growth of drought-resisting trees and shrubs in addition to veritable forests of tree cactus and a rich flora of herbaceous vegetation which follows the periodical wet seasons. No rain fell at La Plata during 1924, and there had been no appreciable precipitation about Point Santa Elena since the season of 1918–1919.[12]

[12] An account of conditions about Point Santa Elena is given in the article cited in *Natural History*, footnote 3.

During the Ecuadorian field work of Mr. Heilner and the writer, which extended from January 29 to March 3, but one rainless day (February 21) and one rainless night (February 24–25) were experienced along this coast.

It may also be noted that there were unusually heavy rains in the mountains. On the same date as the destructive floods in Lima nearly half of the mountain sections of the Guayaquil-Quito Railroad, in Ecuador, were destroyed by floods. The River Chanchan is said to have risen eighteen feet in a single night, washing away numerous houses at Huigra and elsewhere.

FIG. 16—The coasts of northern Peru and southern Ecuador. The heavy broken line divides regions having annual rains (to the east) from those having rains only at intervals of years (to the west). Scale 1:6,500,000.

THE QUESTION OF PERIODICITY

In western Ecuador, as on the coast of northern Peru, the seven-year cycle of rainfall, subject to a certain variability of intervals and intensity, is currently recognized. The length of the period agrees with that of one which has been studied by Clough,[13] but the writer lacks data for attempting a correlation. Precise information regarding rainfall and advances of the countercurrent in the region is exceedingly difficult to obtain, but it is known that one or both of the phenomena (which would seem, indeed, to be inseparable) characterized in greater or less degree the years 1878, 1884, 1891, and 1918. The season of 1925, however, overshadowed all other years within living memory. The interval between 1891 and 1925 suggests at once the 35-year Brückner period, but the end dates are quite at variance with the established wet epochs of Brückner.

We know, at any rate, that the demonstrations of *El Niño* are seasonal and rhythmic, and that the causes behind them are meteorological in the broadest sense. Although we have only the vaguest references to years of rainfall and countercurrent during the historic period previous to 1891, it has been suggested that the march which Pizarro made through Piura, while on his triumphal journey toward

[13] H. W. Clough: An Approximate Seven-year Period in Terrestrial Weather, with Solar Correlation, *Monthly Weather Rev.*, Vol. 48, 1920, pp. 593–596.

Cuzco, was possible only because he chanced to land upon the desert shores during one of the rare *años de abundancia*, or years of abundant water and vegetation.

There are indications in the stratigraphy of northwestern Peru that periodic "wet years" may have characterized the region far back into Tertiary time. Professor Edward H. Berry has kindly supplied the writer with the following note relating to this subject.

> The Tertiary is many thousand feet in thickness and is characterized almost throughout by pebble beds at intervals in clay shales or sandstones, and the pebble beds are usually crowded with molluscan shells, sometimes of but few species. The ages represented are Middle and Upper Eocene, Oligocene, and Lower Miocene (there is no Middle or Upper Miocene or Pliocene). These pebble beds seem to be most regular through about 2500 feet in the middle of the Eocene of the region, becoming less regular and less prominent a feature some 5000 feet below the top of the Eocene; they do not again become prominent except for an interval of about 750 feet near the middle of the Lower Miocene. During the Pleistocene[14] the succession of coastal terraces appear to fulfill admirably the conditions of periodic flood years, not only in the character of the materials but in the resulting topography, and this may well have been true of the Middle and Upper Miocene and Pliocene during which the mountain barrier to the east was rising to great heights and whose deposits are not available for study.

Finally, Dr. H. H. Clayton has made by letter the following comments bearing upon the possible ultimate causes of the phenomena here described.

> Researches on the influence of changes in solar heat radiation upon our atmosphere have shown that the belts of high and low pressure normally in the atmosphere are displaced to and fro with changes in solar radiation. When the radiation is high, the belts of high pressure near the 30th parallels are displaced toward the poles, and when the solar radiation is below normal they retreat toward the equator. Part of the evidence for this statement is found in my book "World Weather" (pp. 244–251).
>
> . . . Because of lack of data we have not yet examined in detail the position of the high area in the south Pacific during 1922 and 1923, but there was a marked retreat of the northern high pressure areas toward the equator, and I have no doubt that the same thing took place south of the equator; in fact your own observations are evidence of it, because as a meteorologist I can see no other way to explain the conditions you report. The solar radiation was unusually low from 1922 to 1924.

[14] T. O. Bosworth: Geology of the Tertiary and Quaternary Periods in the North-West Part of Peru, London, 1922.

AN ICE CAVE IN NEW MEXICO

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NEW Mexico is a land of natural wonders. To such features as the beautifully symmetrical crater cone of Mt. Capulin and the spectacular Carlsbad Cavern, set aside as National Monuments, is now added a new curiosity in the form of an unusually interesting ice cave.

The cave is situated in the western part of the state about fifty miles southeast of Gallup and an equal distance from Grants. It is readily reached by automobile from either town. The writer's party made the visit from Gallup. Leaving that coal-mining town early one morning, we motored southward through the Zuñi Indian Reservation to the Mormon town of Ramah.

A few miles farther east the ruins of some ancient cliff dwellings were visited. Little is known of the ruins in this part of New Mexico, but their number suggests that this country once supported a much greater population than it does at the present time. A stop was also made at Inscription Rock, now known as the El Morro National Monument, where the face of the massive sandstone is covered with inscriptions dating back to the early Spanish expeditions.

The Lava Country

Another run of half an hour brought us to the foot of a great volcanic cone, once used as a signal station and known locally as Cerro de la Bandera, or Flag Butte. The cone rises steeply many hundreds of feet above the plain on which it stands. Its summit has an altitude of 8300 feet according to our aneroid. The slope of loose volcanic cinders is as steep as unconsolidated material will lie. The lower part is covered with pine trees; the upper part is nearly barren. The great crater depression in the top of the cone was estimated as about 500 feet deep. The rim is broken away on one side as if the last flow of lava had broken through and carried away the material from thence.

Cerro de la Bandera stands at the northern margin of a great lava field—rough, black *malpais* (bad country)—that stretches away as far as the eye can reach. It is known as Los Veteados, or the veined country, because of great cracks formed when the lava cooled. Many of these "veins" or cracks lead down into hollows where the molten lava escaped during the closing stages of flow, leaving the solidified

crust arching over caves. These caves have long been used as places of refuge. Many a criminal has escaped capture by retiring to some such refuge in the *malpais*, where pursuit is practically impossible by those who are not intimately acquainted with the devious passages. The Apache warriors were wont to leave their women and children in these natural shelters when they went on the warpath or set out on foraging expeditions. Judging from the numerous rock shelters and fragments of pottery of ancient design, the custom was a very ancient one.

Features of the Ice Cave

The ice cave, which was our objective, is no exception to the rule. Evidences of former occupation were found on all sides of it. Doubtless this was a favorite refuge, because within the cave is a permanent supply of good drinking water. The cave is located on the side from which the crater rim was carried away and is so situated that it is best examined in the morning light. It is about 50 feet below the surface and opens into a large depression formed by the collapse of the roof. Apparently the last flow of lava from the crater, perhaps the one that broke through the rim, was 50 to 75 feet deep. Where the cave is situated the lava crusted over to a depth of 50 feet or more, when the rock below, still in a fluid state, flowed out leaving a long irregularly shaped hollow. The crust above this cave collapsed in several places. But in other places it remains arched over the hollow. The largest depression thus formed constitutes the entrance to the ice cave.

We clambered down the wall of jagged rocks into the large opening, made our way over the angular blocks of fallen rock that once formed the roof, and finally entered the dark cavern, where artificial light was needed. There we saw before us a perpendicular wall of clear blue ice extending entirely across the cave, a distance of about 50 feet, and rising 14 feet above the floor. Other visitors had been there before us, bringing with them the trunk of a small pine tree which served as a rude ladder. By means of it we climbed to the top of the ice.

The upper surface of the ice is level for about 30 feet back from the face and then gradually slopes inward toward the back of the cave. The total thickness of the ice is not known, for the bottom is nowhere exposed. Most of the ice is clear and has a bluish tint. It lies in horizontal layers separated by thin seams of impure ice. At one horizon near the top are several large blocks of rock apparently fallen from the ceiling and later covered.

We took the temperature in several places in the ice cave. It was a warm day in August. The water standing in the pool at the base of the wall of ice, the air above the ice and in the cave back of the main

FIG. 1

FIG. 2

FIG. 1—The edge of the *malpais*, showing the rough, barren flow lava in the foreground and the forest in the distance beyond the limit of flow.

FIG. 2—The interior of the crater of Cerro de la Bandera. The pine trees on the inner slope, 50 to 75 feet high, give an idea of the size.

mass, and the rock of the inner walls all showed a temperature of 32° F.

The effect of the summer heat is seen near the mouth of the cave. The ice is so far from the opening that the rays of sun never strike it; but a warm current of air occasionally reaches it. The winds at the surface cause shifting of air currents in the sink and to a less extent in the cave itself. The net result of the summer activity of the

FIG. 3—The ice cave. Looking back into the cavern over the top of the ice. The three persons in the foreground are standing at the foot of the ice wall, which is 50 feet long and 14 feet high. The man above is standing on the great mass of ice which extends back 30 feet and then slopes gently downward toward the back of the cave. The irregular masses in the foreground are rocks from the collapsed roof.

warm currents is shown in the form of the ice where the face is curved, suggesting swirling currents of warm air.

ORIGIN OF THE ICE AND SCIENTIFIC INTEREST

The occurrence of perpetual ice in large quantity in caves is rare, although many instances of small volumes of ice are known. Edwin Swift Balch described a large number in a volume on "Glacières or Freezing Caverns" (1900), and a recent publication by Georg Kyrle, "Grundriss der theoretischen Speläologie," contains additional information. Also many ice caves in the lava fields of the Northwest have been examined but not described in print. None, however, that have come to the writer's notice excel that at Cerro de la Bandera in volume of ice. The occurrence of ice formed in caves has given rise to much speculation and in some instances to wild conjecture. However, one need not look for extraordinary causes in explanation of the ice, nor is it necessary to appeal to chemical changes, exhalations of

gas, or other rare phenomena. The ordinary changes in weather and the well known characteristics of scoriaceous basalt appear to be quite sufficient to account for the ice in our ice cave though no extended observations were made in it.

At the altitude of this cave, 7300 feet or more above sea level, the cold of winter is severe, and freezing weather lasts many months. During times of frost the cold air circulates among the rocks, cooling them below the freezing temperature. Water flowing into the cooled spaces congeals. During thawing weather warm air circulates through the open spaces and warms the rocks. If, on the whole, the warmth prevails, as it does in most places, the ice of winter melts in summer, and there is no perpetual supply. But in a few favored places the summer heat does not overcome the winter frost, and the ice formed during the cold season is not entirely melted during the warm season. In brief, there is a lagging of effect in the change of temperature. The "cold" of winter is conserved in the cave just as it is in an ice house. It is even possible that the temperature of the rocks to a considerable depth beneath the surface may be lowered so far below the freezing point during a long cold period that freezing may continue after all ice has melted from the surface. The accumulation of ice in spring and early summer has been noted in several places. Its formation in the case of the Decorah Ice Cave in Iowa has been described by Alois F. Kovarik.[1]

It may not be out of place to call attention to the possibility of making scientific observations here of a timely nature. The lava in which this cave is situated results from a relatively recent volcanic eruption—how recent is not known. The liquified rock flooded the lowland east of the Zuñi Mountains and flowed northward to the San José River at Grants, where the congealed lava, as seen from the railway, appears quite fresh.

This is one of the lava flows said to be so recent that it might have taken place in historic time. Yet on this flow stand large pine trees, and in it is a cave with a body of ice of such nature that it must represent accumulation through many years. Also on the lava near the cave are the remains of a prehistoric people.

The banding of the ice in the cave suggests a possibility of working out a chronology. The mass is made up of layers of ice. Each layer may represent a year's accumulation or it may represent a climatic cycle. This could probably be determined by careful observation. It is not impossible that the climatic changes recorded in the ice might supplement the chronology obtained by studying the growth of trees. The large pine trees of this region offer an attractive start for such a comparison.

[1] A. F. Kovarik: The Decorah Ice Cave and Its Explanation, *Scientific American Suppl.*, Vol. 46, 1898, November 26, pp. 19158–19159.

QUELPART ISLAND AND ITS PEOPLE

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University of Michigan

QUELPART Island lying fifty miles south of the Korean coast may be distinguished from afar by the towering peak (6785 feet), Mt. Auckland, Kanra San. The long slopes and subsidiary spurs of this great volcanic cone comprise the 715 square miles of the island. Quelpart was first brought to the attention of the western world by one Hendrick Hamel,[1] a Dutch sailor, who was shipwrecked upon its coast in 1653. Before that date Dutch navigators in the Cathay trade had come in contact with the island and, noting its similarity in form to the galiot, had dubbed it "Quelpart," a slang word for such ships. This has been adopted in conventional usage though rightfully the name is Saishu To, Japanese, Chyöijyudo, Korean. Nothing of a detailed or purely geographic nature has, to the writer's knowledge, ever been published on it in any western language.

Numbers and Origin of Population[2]

The population of Quelpart, according to the census of 1921, was 198,719,[3] of which less than one half of one per cent was listed as foreign, chiefly Japanese. The average density of population, 280 persons to the square mile, is not particularly high when compared with figures for some other parts of Asia, which are no better endowed climatically. For Quelpart, however, it means an extremely low standard of living. The area fit for agriculture is limited—only 40 per cent is thus available—and soil, surface, and drainage conditions generally are unfavorable. Even judging by the worst Asiatic standards, the lot of the native is hard. How much of the poverty and the shiftless manner of living is due to a miserly environment and a too dense population and how much to the past cannot be said. For

[1] Verhaal van het Vergaan van het Jacht de Sperwer . . . door Hendrik Hamel (Linschoten Vereeniging No. 18), The Hague, 1920.

For digests in English see: John Pinkerton: A General Collection of the Best and Most Interesting Voyages and Travels in All Parts of the World (17 Vols., London, 1808–14), Vol. 7, pp. 517 *et seq.*; W. E. Griffis: Corea, Without and Within, Philadelphia, 1885; and the reproduction of the old English translation in *Trans. Korea Branch Royal Asiatic Soc.*, Vol. 9, 1918, pp. 91–148.

[2] 1921 statistics throughout are taken from the 1921 census, Government Printing Office, Kiejo (Seoul), Chosen, 1923. Use has also been made of other official statistics from the Governor General's Office, Kiejo, Chosen.

[3] This is a marked decline on the figures for 1919, 201,336, a fact to be accounted for by the serious typhus epidemic in 1919 followed by a minor smallpox epidemic in 1920.

long, Quelpart was a penal colony of Korea,[4] being that country's most outlying and isolated possession. Sir Edward Belcher[5] was struck by the wanton exploitation of the land and surmised that it was due to the lack of interest on the part of those who could never own land and expected to leave the island when their period of incarceration had expired. Until very recently, too, most of the land was held under public or village ownership,[6] a condition which does not encourage individual effort.

The origin of the people of Quelpart is still open to question. Doubtless many strains are represented in the present population. Though isolated, the island lies in no cul-de-sac: from the earliest times it has served as a stepping stone between Korea and China in the west and Japan and the Loo Choos in the east.

The sea-roving proclivities of the Neolithic man of coastal China probably led him at an early date to Quelpart,[7] across the five hundred miles of enclosed waters of the Yellow Sea. This theory is especially plausible when we consider the westernmost branch of the Kuro Siwo and its path along the Chinese coast and thence northeastward to the island. The peak of Kanra San, as we have said, attracts attention from great distances at sea. The Mongoloid invasions of Japan, embracing various groups from the Amur to the Si, must have passed largely by the way of Korea and have included Quelpart. The Polynesian and Malaysian strains which, at a later date, filtered northward along the Loo Choo bridge also probably left their mark. Several attempts have been made to prove a dominant southern origin of the people,[8] but other investigations point strongly to a common origin with the Japanese.[9] At an early date, however, Quelpart came under the domination of the nearer mainland, paying tribute to various states in succession that established themselves in the Korean peninsula. Because of its strategic position Quelpart played a part in the Mongol invasions of Japan. In 1272 the island was occupied by the troops of Kublai Khan, and the ancient and nominally independent kingdom of Tamna was brought to an end. The famous timber of the island was badly exploited in the building of the second great Mongol fleet. The Mongols remained in possession until they were forcibly driven out 100 years later. During their lax hold, after

[4] H. B. Hulbert: The Island of Quelpart, *Bull. Amer. Geogr. Soc.*, Vol. 37, 1905, pp. 396–408; W. E. Griffis: Corea, The Hermit Nation, 7th edit., London, 1905, p. 201; "De Sperner door Hendrik Hamel" (see footnote 1) also contains interesting accounts of peoples; Sir Edward Belcher: Narrative of the Voyage of H. M. S. Samarang, 2 vols., London, 1848. Volume 1 has an interesting account of experiences with the people.

[5] Belcher, *op. cit.*

[6] Hulbert, *op. cit.*

[7] C. W. Bishop: The Historical Geography of Early Japan, *Geogr. Rev.*, Vol. 13, 1923, pp. 40–63.

[8] Hulbert, *op. cit.*; Belcher, *op. cit.*

[9] W. G. Aston, transl.: Nihongi, 2 vols., London, 1896; reference in Vol. 2, p. 323, note. An ancient myth tells of the first three men of Quelpart securing wives from among the daughters of the king of Japan.

the second invasion of Japan, Japanese marauders used Quelpart as a base for attacks on the Korean coast.[10]

The island which had become an integral part of Koryu was later absorbed as such into the greater Korea. The culture, consequently, is today quite dominantly Korean. Yet marked departures are often

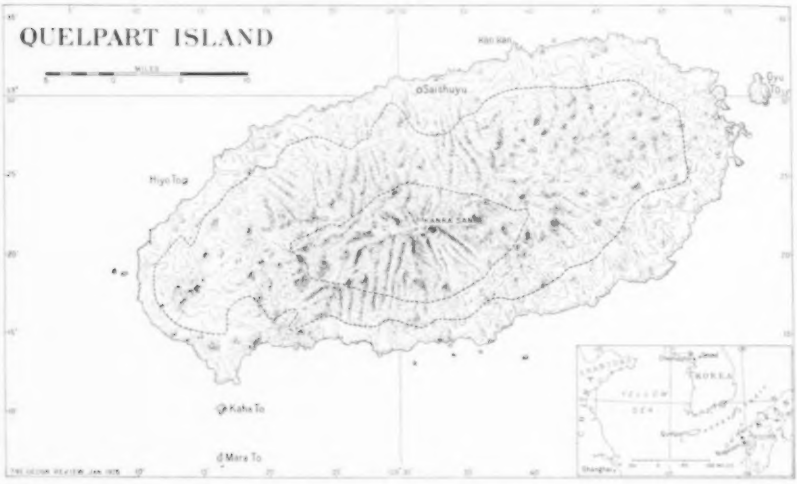

FIG. 1—Quelpart Island, Saishu To. Drawn from a photoprint of the Japanese chart No. 1208 kindly supplied by the U. S. Hydrographic Office. The dashed lines delimit the three natural regions—Coastal, Middle, and Mountain. Scale approximately 1: 850,000. Inset map shows the situation of the island.

encountered which may be either a result of local development, due to isolation, or past contact with Japan and the South.

THE DISTRIBUTION OF POPULATION

With the rather unimportant exception of a few isolated hovels on the upper slopes and small valleys of Kanra San, all of the people of Quelpart live in villages. This allows an accurate study and map presentation of population distribution. It will be noted that by far the majority of villages occur in a belt encircling the island in close proximity to the sea. A second and less important belt occurs some distance inland, where the lower mountain slopes give way to the coastal region of low relief. Other villages are found at the intersection of lines of communication and at points of contact between natural regions.

This distribution corresponds very closely to the natural divisions of the island. The degree of slope is consistently greater with increase in elevation, and there has grown up a local recognition of

[10] Nakada Yamada: Ghenkō; The Mongol Invasion of Japan, London, 1916.

three natural entities—the Coastal, Middle, and Mountain Districts (Fig. 1). It is also of interest to note that the minor political divisions (*ri*, or village) which, no doubt, are remnants of the old social organization of Tamna, coincide with the actual physiographic limits of the different districts. The major political divisions (*myum*, or

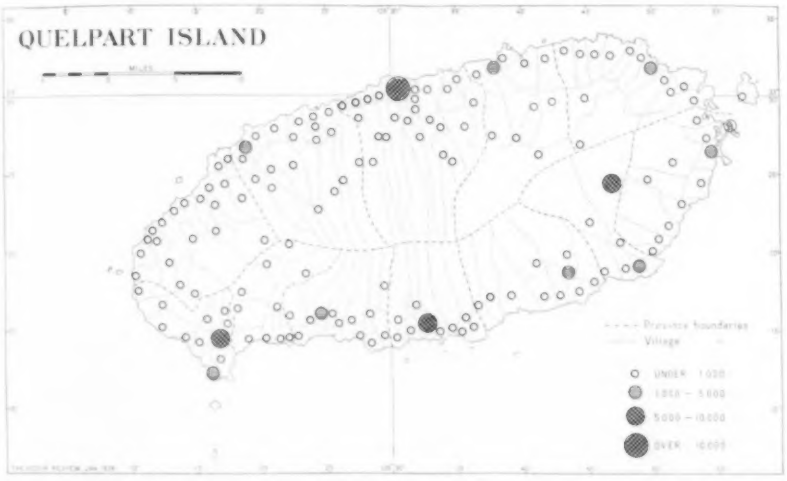

FIG. 2—Quelpart Island, showing population distribution. Data from 1921 census statistics (Governor General's Office, Kiejo, Chosen, 1923).

province), of more recent origin, are roughly triangular with apex in the mountains and base along the shore.

THE COASTAL DISTRICT

The Coastal District comprises one-third of the land area of the island and contains almost two-thirds of its population, or an average density of about 480 persons to the square mile. In some places it is composed of flat, narrow strips. In others it is gently sloping. It also includes certain high narrow plains, sharply cliffed at their sea edge. The inner limit is marked by the foothills, steeper slopes, and dissected plains of the Middle District. Here and there are seen small volcanic cones that seldom reach over 350 feet in elevation. Centuries of contour plowing has given them a smooth and symmetrical configuration. In the days of Japanese freebooters and other sea marauders the cones were fortified and served as excellent watch-towers and signal points.[11]

Both land and sea contribute to the livelihood of the coastal dwellers. The great majority of families own their own farms and supplement their income from the land by products from the sea.

[11] Belcher, *op. cit.*

In this district are found the larger villages, as well as the most dense population, and commerce and general business are largely monopolized here. It, too, contains the best agricultural land and the highest percentage of arable land.

Climatic conditions in this belt may be illustrated by figures for Saishu, the capital city, on the northern coast. The latitude is 33° 31′ N.; altitude of station, 21 meters. The absolute maximum temperature for the period 1918–1921 was 93.5°, the minimum 25°. The temperature régime may be compared with that of Nagasaki with a mean annual temperature (25-year period) of 60°, the warmest month 80°, the coldest 42°, absolute extremes 98° and 23°.

TABLE I—MEAN TEMPERATURE (1918–1921) AND RAINFALL (1916–1923) AT SAISHU*

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Year
Temp. °F. .	40	42	46	55	61	69	78	79	72	64	54	45	59
Rainfall Inches . .	2.6	2.8	3.3	4.7	2.6	7.7	8.6	6.4	7.3	3.3	2.7	2.5	55

*Data of the Meteorological Observatory of the Government-General of Chosen, Zinsen (Chemulpho).

The rainfall of Mara To off the western end of the island, for the period 1916–1923 was 44 inches, for Gyu To, off the northeastern end for the period 1912–1916 it was 37 inches.

The propinquity of Quelpart to the great land mass of Asia brings it largely under the control of the monsoon winds. Hence the northern side of the island as a whole receives less rain than does the southern, open as the latter is to the moisture-laden southeast winds of the summer. The central mountain mass, too, affects this distribution. The strongest winds blow from the north and northeast and arouse great apprehension among the farmers when they occur in late spring or early fall, as they often herald frost. Strong winds are also of frequent occurrence from the northwest and southwest but seldom if ever from the south. In early autumn typhoons sometimes strike the island, causing considerable damage. It is common to find the house roofs, especially in the southern part of the coastal district, weighted down with rocks against such storms. On the northern coast frosts occur regularly in winter, while the southern coast, which is on the average 6°F. warmer, is frost-free. The production of cotton, oranges, and winter vegetables is confined to the southern section.[12]

[12] In 1921 there were 1325 acres under cotton, 32 (43,000 trees) under oranges, 130 under mulberry: 854 families engaged in spring sericulture produced 1455 bushels of cocoons; 620 in winter sericulture, 753 bushels of cocoons.

It is, also, the only part of the island in which sericulture is carried on. Fogs are common along the coast, often causing trouble to navigation.

The Water Supply Problem

Along the inner margin of the coastal district, a line of small springs occurs. The distribution of these springs corresponds very

Fig. 3—Kanra San (Mt. Auckland) seen from the sea.

closely to the distribution of villages in the secondary inland belt. Other springs occur along the stream valleys, both near the coast and in their upper reaches. Here, again, there is a marked correlation between village and spring distribution. A deficiency in both quantity and quality of water is one of the most difficult problems faced by the people of Quelpart. There are no regularly flowing streams, and the water of the few springs is commonly acrid. With few exceptions the people must depend largely upon storage tanks for their supply. Considering the abundant rainfall and the large quantity of water released by the melting snows of the mountain tops, this condition seems strange. The porosity and chemical composition of the base rock, however, explain both the deficiency in quantity and in quality.

Some fifteen streams rise in the upper levels of Kanra San and flow either north or south. In times of heavy rain they rise rapidly and reach the sea in their surface channels. But within ten hours after the rain has ceased they have entirely disappeared before reaching the lower slopes of the mountains. Even in early spring when the snows are melting rapidly or in times of light rains the stream beds at lower levels are dry. In several places, however, under-

ground streams have been noted at a depth of not more than ten feet, and, where the slope gives way to a plain, springs often occur in the surface channel or near it. Otherwise the water follows its subterranean channel out to sea. The main crops of the island are distinctly drought-resistant: very little "paddy" or wet-field rice can be raised, and much difficulty is also encountered in constructing ponds for watering live stock and for fish culture.

FIG. 4—Bottle-neck harbor on the eastern coast of the island (Goshori Ho on U. S. Hydrographic Office Chart No. 5461, Gyu To and Approaches, 1924). Note the characteristic volcanic cone.

SOILS, AGRICULTURE, AND OTHER INDUSTRIES

The unpalatability of the spring water and the normal acidic condition of the soil are explained by the prevalence of sulphurous constituents in the rock, which is volcanic in origin. Large and small rocks occur in great quantities at the surface. Stone fences are found in all parts of the island, often dividing fields into ridiculously small units. Plowing of the land, especially with primitive tools, is difficult. Yet this prevalence of rock is of some advantage. It retards the tendency of the soil to blow badly when dry. It is also the universal building material for all types of dwellings and for the walls which furnish protection from the grazing animals allowed to roam at will.

Near the coast sand and shell fragments enter into the soil composition and help correct the natural acidity. Here the soils are quite deep and are underlain by a red clayey subsoil, which aids in the retention of soil moisture. The deepest soils and those with the highest organic content are found in the northern portion of the coastal district, largely because of the gentler slopes and the occurrence of frost. In the northeastern part of this section is a deep black soil which

occurs nowhere else on the island. It is formed from the disintegration of an ancient volcanic rock. The most recent lava flows (1003 and 1008 A. D.)[13] were to the north and south of Kanra San and did not cover the eastern end of the island. In the lower portions of the valleys, notably about the capital city, are small quantities of alluvium.

As may be expected, the coastal district far surpasses other parts of the island as regards production. All of the general crops are raised here and give higher yields than elsewhere. Fertilization is practiced, seaweed and fish forming the chief source of fertilizer in the coastal district: animal refuse is used generally elsewhere. Crop alternation is followed, and the land is seldom allowed to lie fallow. In the southern part some of the land is under cultivation all of the year, winter vegetables and other crops being raised. Most of the land, however, is grazed during the winter months. The paddy rice raised in the island, 250 acres in 1921, is found here, and so too are the bulk of the hogs and fowls.

FIG. 5—Two old men of the Mountain District. The dogskin cap commonly used is peculiar to the island. Note the scoriaceous nature of the rock.

From the study of eleven normal farms in this district, the following crop acreage was computed. Average size of farms, 5¼ acres: barley 1¼; millet 1¾; soy beans ¾; sweet potatoes ¼; cotton ¼; panic grass ½; Indian beans ⅛; rice ⅛; vegetables 1/40; dwelling, etc. ¼.

The value of property is two to four times that of the best land in the Middle District and ten to thirty times that of the Mountain District. The average size of farms is comparatively small: 5 acres against 7 in the central and 13 in the mountain region. There are, however, no large landowners, both land and wealth being well distributed.

The fishing industries, constituting an important source of food and fertilizer, contribute largely to the support of the average coastal family. Fresh fish, dried fish, shellfish, and edible seaweeds are peddled inland by traders and are exported to Japan and Korea. In 1921 they constituted 25 per cent of the total exports. The coarser types of seaweed, which grow near the shore, are used as ferti-

[13] The original source for this information is doubtless the "Yo-ji Seung Nam" (the ancient Korean Geographical Gazetteer).

lizer and are exported to Japan. Pearl and abalone shells are also exported.

Double-decked flatboats, driven by a large oar at the rear end, are used; and most of the fishing is done with hook and line, as the sea floor is generally too rough to allow the use of nets. The gathering of seaweeds, shells, and pearl oysters is practically all done by the women, who are expert divers. In recent years, the Japanese have entered the pearling trade with modern diving apparatus and have almost completely exploited the oyster beds. Attempts have been made to establish fish culture, but with little success on account of the lack of good water and the difficulty of maintaining ponds. The canning and drying of fish and the manufacture of salt are of growing importance.

Practically all of the other industries are of the household type and include the making of coarse fabrics from "Asa" hemp and cotton, straw mats and sandals, fine-toothed wooden combs, the tanning of hides, and the preparation of bone and hair by-products.

Cities and Villages

Of the cities of the Coastal District, Saishu, the capital (Fig. 6), is far and away the largest and most important on the island. It contains a population of over 10,000, the government offices, the bank, and the chief business houses. Its situation on the northern coast, no doubt, was favored by the more ready access to Korea. The site and much of its importance are due to the presence of a group of springs, which in quantity and quality of water have no peer in any part of the island. The broad, short valley, at the mouth of which the city is situated, and the Koryung Plain, extending eastward from it, make available a considerable quantity of arable land and support a cluster of small villages, of which Saishu is the market center. The city was, a century ago, surrounded by a wall of lava rock about 25 feet in height which enclosed an oblong area five hundred by two hundred yards.[14] Its main gates were two in number, one facing inland and the other the sea. It contained, too, seven bastions with embrasures for small cannon, which were about ten feet higher than the walls. In more recent years, however, these have largely fallen into decay, and the city now occupies a considerable area outside of the wall. The three next largest towns lie on the inner margin of the Coastal District and other important villages on the coast (Figs. 1 and 2). All told, about one hundred of the one hundred and fifty minor villages of the island lie well within the Coastal District or on the line of contact between it and the Middle District.

There are no individual farmhouses in this district, all dwellings being grouped in villages. Their walls are universally of lava rock,

[14] Belcher, *op. cit.*

FIG. 6

FIG. 7

FIG. 6—Saishu, the capital city. Note the stone walls and roofs thatch covered with a few exceptions where Korean tiling is used.

FIG. 7—A typical scene in the Middle District. The animals are full-grown.

and their roofs are of thatch, with the exception of the better houses and shrines, which are tiled. This tile is imported from Korea and is of the usual Korean type, i. e. flat gray tiles fitted closely together with semicircular ones covering the joints.

Connecting many of the chief villages, the main thoroughfare of the island follows the coast for its entire circumference. It is little more than a trail and, during times of heavy rain, cannot be used on account of the torrential nature of the streams, which it crosses at right angles, and the stickiness of the soil when wet. Other less good trails traverse the island, connecting the capital city with important points on the southern and eastern coast. The greater part of the transporting is done by human carriers, in high baskets upon the back. Ponies and cattle, also, are used to some extent as carriers. A considerable amount of coastwise traffic is also carried on, there being many places along the shore where small boats can stop. Small-boat traffic likewise exists between the coastal villages and the neighboring small islands.

The Middle District

The Middle District contains about 37 per cent of the population of the island and comprises almost one-half of its land area. The average density per square mile is approximately 212, or considerably less than half that of the Coastal District. The great majority of villages found in this district occur either near the line of contact between districts or near the upper reaches of the stream valleys. In either case springs may be found and wood for fuel is more easily available. It is impossible to say how much of the support of any village that occurs on the line of contact between the different natural entities is derived from one district and how much from the other: the limits of village property often encompass parts of two districts. Living conditions are similar to those in the coastal area but on a lower standard.

The Middle District includes the foothills, lower mountain slopes, and partially dissected high plains which lie between the Coastal and Mountain districts. The seaward limits have already been delineated. The inland limits are marked by mountain slopes which are, in general, too steep for regular agriculture; roughly it corresponds to the 2000-foot contour level. It is an area of moderate relief and is geographically a unit, based upon the prevalent combination of animal husbandry and farming. This is the pasture area. Most of the horses and cattle of the island are found here. Soil conditions are not so good as in the Coastal District, the soil being thinner and more acidic, and the surface is often badly eroded.

The general crops are raised, but in a more or less haphazard fashion, and no winter crops are grown. Good grass is available, at least

FIG. 8

FIG. 9

FIG. 8—The Confucian shrine at Saishu. Note the imported Korean tiling.

FIG. 9—This small shrine and clump of woods are dedicated to the three founders of the island, supposed to have sprung from the ground at this point. Rice field in foreground.

at the lower levels, all the year. The common practice is to drive the cattle and horses into the mountains in summer and allow them to graze at will during the winter months. Most of the cultivated land is allowed to lie fallow from two to four years out of every six. This, in addition to the small permanent pastures held on most farms, gives considerable year-round forage. There is also a considerable amount of land not fit for agriculture, which is held in common and affords fair pasturage. Little is grown in the way of forage crops, and shelter and water supply are insufficient. In consequence the condition of the animals is poor.

The Mountain District

Above two thousand feet much of the land is buried in deep forests. The lower slopes carry a thick growth of oaks, and at higher levels are found pines of three species, larch, azalia, juniper, and maple. Willows grow along the stream beds. In places the forests are distinctly park-like, and wide stretches of fine "lawn" occur. At present there are 67,030 acres of natural forest and 500 to 600 acres have recently been reforested, partially by the government and partially by private initiative. There is, however, a rather considerable portion which has been cleared and where farming is attempted.

There are no villages within the Mountain District. Here and there isolated hovels of one or two rooms are found, lying in sheltered recesses or clinging precariously to steep slopes. Occasionally a cluster of three or four dwellings is found where a considerable stretch of arable land is available. This district comprises an area of approximately 100 square miles and has a population density of not more than ten to the square mile.

The soil is often not more than two to four inches deep and is very stony. Temperatures are low, and the growing season short. Only the hardier crops can be raised, i. e. buckwheat, barley, and beans. In the favored areas small quantities of sweet potatoes, millet, and wheat are raised. Often the land cannot be cultivated for more than one year in five or ten. The general tendency is to move from place to place as the soil gives out. Much of the land is not privately owned. Agricultural methods are extremely crude. The keeping of bees and the gathering of forest products, such as medicinal plants, constitute important auxiliary occupations. Some live stock is raised, and lumbering gives part time employment to many. Renting land for and tending to the herds from the lowlands during the summer months is also of importance. The standard of living in this district is distressingly low.

THE BIRTHPLACE OF CIVILIZATION

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LAST winter the oldest remains of a civilized people were found in Iraq by the Joint Expedition of the British Museum and the University Museum of Philadelphia. The mound that Mr. Leonard Woolley, Director of the Expedition, is now excavating is called Tell-el-Obeid, the ancient "Ur of the Chaldees"; it lies on the south bank of the Euphrates, a little more than 100 miles from Basra. His discoveries were quite sensational, for they included a contemporary inscription of a "mythical" king and a masterpiece of an art whose very existence had hardly been suspected.[1] The inscription of A-anni-padda, son of Mes-anni-padda, is the earliest dated historical document in the world—the discoverer puts it somewhere in the fourth millennium before the Christian era, probably about the middle. The art is Sumerian, and the site of Tell-el-Obeid has provided the oldest known remains of Sumerian civilization. It will be profitable, therefore, to summarize the facts known about the earliest cultures in this region and in that other early home of civilization, Egypt, and to propound a hypothesis which may account for the origin of both civilizations.

The Painted Pottery Folk of Iraq

The Sumerians of the fourth millennium before the Christian era were not the first inhabitants of Iraq. On the sites where they built their temples at Ur and Eridu (now Abu Shahrain) there lived a prehistoric people whom we may call the Painted Pottery Folk. They were entirely distinct from the Sumerians; and it is possible that the sites where they had lived had both been deserted for some time when the Sumerians arrived. They "were not only able to make exquisite pottery (artistically painted and almost certainly made without the wheel) but were also good agriculturists. They used stone hoes to till the ground, reaped their crops with clay sickles, and rubbed their corn with stone querns into flour; their spindle whorls show that they could weave; for weapons they had bows, slings, and axes of ground stone; for ornaments it is probable they also had delicately-made obsidian pins, and perhaps carnelian beads . . . they were unable to write and seem not to have been able to carve

[1] The Sumerian masterpiece referred to is a frieze of cattle being milked; and statues of bulls also adorned the façade of the temple of A-anni-padda.

stone, which may doubtless be explained from there being no certain indication of their possessing metal. For food, besides cereals, they ate fish and fresh-water mussels, and doubtless, as they had slings and bows, birds and small animals."[2] They may have been able to build mud-brick houses, but more probably they lived in reed huts like the modern Arab. These people occupied the hills of Abu Shahrain before the Sumerians.

It is difficult to prove a negative; but it is stated that the Painted Pottery Folk, unlike their Sumerian successors, had no domesticated animals, being agriculturists, hunters, and fishers only. This conclusion is strengthened by the abundance of arrowheads found amongst their remains, in contrast again with the Sumerians who did not use the arrow in those early days.

Little else is known about these Pre-Sumerian folk. Painted pottery of identical character has been found on the island of Bender Bushire, in the Persian Gulf. At Susa pottery painted in the same style was found by the French "Délégation" under 80 feet of accumulated strata; and again at Musyan not far off. The earliest phase of this very fine abstract style seems to be found in the Susian pottery. Consequently Mr. Frankfort[3] infers that the Painted Pottery Folk of Iraq migrated there from the neighborhood of Susa and that at Musyan, 150 kilometers to the west, we have an intermediate station on their journey.

However this may be, we really know very little about these Neolithic hunters; and we are not now primarily concerned with them. They disappeared, and they did not plant the seeds of an enduring civilization. It seems certain that they came from the north; possibly the climate of Persia was beginning to get drier, and the game on which they subsisted was retreating inland to the mountains southward and to the well-watered plains of the Two Rivers. Desiccation would make Iraq more, not less, habitable in these remote ages, nearer perhaps to the Ice Age than we are to them.

The Sumerians

Civilization was founded in Iraq by the Sumerians, who brought with them two epoch-making inventions—copper implements and writing; together with, as has been said, domestic animals. They wore a peculiar form of dress—a kind of pleated skirt (called by the Greeks a *kaunakes*). The upper part of their body was naked. Whence did they come? The *kaunakes* is not a garment for a cold climate;

[2] R. Campbell Thompson: The British Museum Excavations at Abu Shahrain in Mesopotamia in 1918, *Archaeologia*, Vol. 70, 1918–1920. pp. 109–110.

[3] H. Frankfort: Studies in Early Pottery of the Near East, I: Mesopotamia, Syria and Egypt, and Their Earliest Interrelations, *Royal Anthropol. Inst. Occasional Papers No. 6*, London, 1924, p. 39.

it suggests the warm south; and Mr. Frankfort[4] gives convincing reasons against a northern origin, which indeed is unsupported by any archeological evidence. The northwest has never been suggested and is quite impossible. There remain only two possible directions, the southeast and south. In choosing between these two possibilities we have but the scantiest evidence to guide us. Apart from the *kaunakes*, which might suit either, all we know is that their

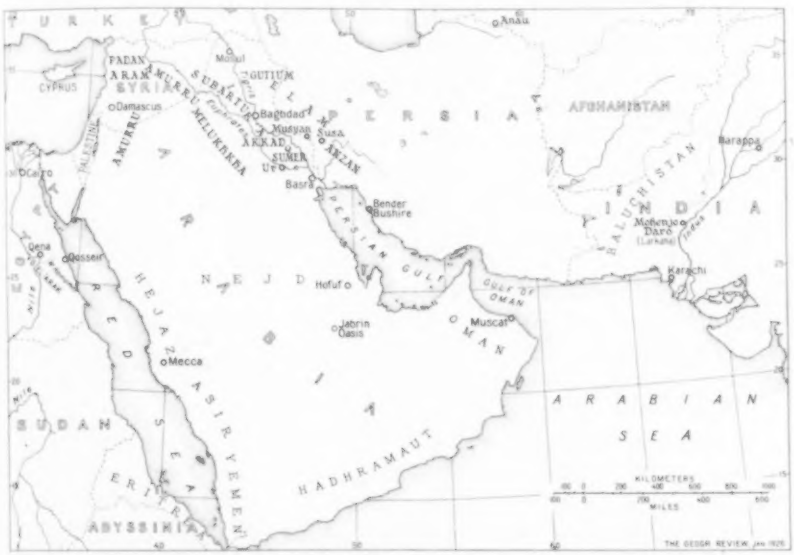

FIG. 1—Map to show the localities mentioned in the text. Scale 1:38,000,000.

religion, as we see it at Ur and elsewhere, is that of a mountain people. They made huge artificial hills for their temples, owing to lack of natural "high places" for worship on the plains. Their script, according to the best authorities,[5] must also have developed in a mountain region and was certainly invented before they reached the plains.[6]

RELATIONS WITH INDIAN CULTURES

Dr. Hall[7] has suggested that they may have come from India; and recent discoveries in that country have provided sensational evidence of an early and hitherto unknown civilization there. These discoveries were made at Mohenjo-Daro, in the Larkana district of Sind, and at Harappa, on the Ravi River. Underneath buildings of

[4] *Op. cit.*, p. 87.
[5] *Ibid.*, p. 91.
[6] British Museum Guide to the Babylonian and Assyrian Antiquities, 3rd edit., 1922, p. 18.
[7] H. R. Hall: Ancient History of the Near East, 5th edit., London, 1915, pp. 173–174.

much later times (third century before the Christian era and later) were found brick buildings and remains of a far earlier period. The culture belongs to the Copper Age, and amongst the finds are certain inscribed seals "which appear to be exactly similar in shape to square stamp seals which are commonly found at Susa and on Babylonian sites of the early period—say about 3500 B. C. to 2500 B. C. The bulls are distinctly Sumerian in appearance. . . . As to the signs on the Harappa seals [i. e. those from one of the two newly-discovered Indian sites] which obviously form some kind of writing, the illustrations will sufficiently show that nine of these signs very closely, and seven partially, resemble the Sumerian writing; while many of the others may prove to be related. . . . Above all, the numeration appears to be the same. . . . These close resemblances . . . cannot be accidental. The people who made these seals must have been in very close contact with Sumerian civilization and have borrowed their artistic style and the basis of their writing from the Sumerians at some period about 3000–2800 B. C."[8]

Did the Sumerians, then, really come from India? We think not; there are great objections to that hypothesis. Let it, however, be clearly stated at the outset that the resemblances referred to above appear, even to one unfamiliar with Sumerian art and writing, to be quite convincing; and one is amazed that they should not have been observed either by the discoverer, Mr. Banerji, or the Director General of Archeology in India, Sir John Marshall. If, however, the date suggested for contact with Sumeria, B. C. 3000–2800, prove correct, that is several centuries after the arrival of the Sumerians in Iraq, even reckoning by the shortest chronology; so that if there was a derivation of script or style, as there certainly was, the Indian culture must have derived from Sumeria. There may, of course, be earlier forms of the Indian script still undiscovered in the 60 feet of stratified deposits or on other sites; but both the Indian script and the Sumerian script of 3000–2800 B. C. are highly developed and conventionalized. The Sumerian, we know, had even then a long ancestry, going back to a pictorial script; and it would be rather remarkable if in both countries the lines of evolution were so closely parallel for (perhaps) a thousand years. Had the Indian script resembled the earliest pictorial writing of Sumeria, it might have been possible to argue that the Sumerians originated in India. But, as we have seen, no traces of the pictorial script have been found there; the resemblances are to a much later stage in the Sumerian writing, when it had already become specialized into conventional forms.

In at least four other regions civilization was flourishing when most of Europe was still in the Stone Age. In Crete it began early in the

[8] C. J. Gadd and Sidney Smith: The New Links between Indian and Babylonian Civilisations. *Illust. London News*, Oct. 4, 1924, p. 614.

third millennium, if not before, and embraced the adjacent islands and mainland. Asia Minor is still, for those remote ages, an unexplored territory; but that it was an early center of culture is proved by tantalizing hints from the lands around it.[9] China is still completely unexplored, save for its newly discovered Neolithic painted pottery. But it is otherwise with Egypt.

Contemporary Egyptian Civilization

In Egypt the historic period began, even according to the "shorter chronology," about the middle of the fourth millennium. Before this dynastic period was a long prehistoric civilization, separated into two (or, according to the latest reports, three) successive phases. With these we are not much concerned; it will be enough to note that the last phase, immediately preceding the first dynasty, was characterized by pottery often decorated with ships and in a style which, like the earliest at Susa, Mr. Frankfort calls "abstract." There is, however, no geographical connection whatever between the two styles, which in content are quite dissimilar. It has been suggested that the people of this last prehistoric phase entered Egypt from the eastern desert. Since they certainly did not come from Nubia, there is little doubt that this suggestion is correct.

It is probable that the dynastic civilization was introduced, as in Sumeria, by an invading race; but the development of culture is continuous and unbroken from prehistoric to historic; and although, as we shall see, foreigners must have come in, they did not necessarily come under arms. That much is evident from the effects produced by their presence. The indigenous culture was disturbed by their influence, but when the foreigners were absorbed, or ceased to come, the older culture reasserted itself. The detection of that foreign element in the culture of the prehistoric and early dynastic Egyptians is an admirable example of archeological finesse. Let us briefly examine it.

Asiatic Influence in Early Egypt

The first sign of something that is not Egyptian appears towards the close of the prehistoric period. The most remarkable single object betraying influence from outside is a carved ivory knife handle in the Louvre, found recently at Gebel-el-Arak. Mr. Frankfort expresses the unanimous opinion of Egyptologists when he asserts[10] that this knife handle "has confirmed the existence of Asiatic influence in early Egypt beyond any possible doubt." At the top, on one side, is a man or hero, dominating two powerful lions between which he

[9] Frankfort, *op. cit.*, p. 88 *et passim*.
[10] *Ibid.*, p. 122.

stands. This antithetic arrangement is itself characteristic of Mesopotamian art, and the subject recalls "the cycle of legends known as the Gilgamesh epos. The garment which the hero on the handle wears is as certainly Mesopotamian as his very full beard and cap." Below are two very un-Egyptian dogs; and a lion below them jumps on the hind quarters of a bull which "quietly strolls on, as if nothing was happening." The theme and its treatment are not Egyptian; for the theme is Mesopotamian, and the style of its treatment is "abstract," in the sense with which Mr. Frankfort uses the word.

There are other evidences of the same influence acting upon prehistoric Egyptian art. Mr. Frankfort cites the motif of entwined serpents and the custom of representing mountains or ground in some of the carved scenes. This latter feature is plainly un-Egyptian; on the purely native sculptures of this period—such as the other knife handles, the slate palettes, and the vases—the objects figured are dumped down with little regard for any decorative arrangement or scheme of values. They have plenty of vigor taken singly and individually, but the whole design lacks balance.

Mr. Frankfort concludes his argument by emphasizing the difference in style between the works of purely Egyptian art and those where foreign influence is perceptible; and he calls attention to the early and complete disappearance of this influence. "These themes possess a common feature which characterizes them, as a whole, as foreign to the Egyptian art. That common feature is their unrealistic purely decorative character. Whatever transformations the natural forms have to undergo, when in the Egyptian reliefs they are translated from the three-dimensional into the two-dimensional world, it is actual life throughout which is pictured, and in a matter-of-fact way too. . . . But in Sumer no artist ever displayed this eager wish to capture life. In almost all cases he was satisfied with a general indication of what he wanted to represent. . . . [The designs on the seal cylinders] are purely abstract, symbolical, and are dominated by the laws of decorative composition. In the last instance this contrast between Egyptian and Mesopotamian art is exactly the same as that between hieroglyphic and cuneiform writing, *it is an essential difference in mentality* . . . the contrast between drawing and writing."[11]

This contrast appears to us to be rather overemphasized. The frieze from Tell-el-Obeid, of the cows being milked, is decidedly realistic, and so indeed are some of the other art products recently brought to light there. They had not, of course, been revealed when Mr. Frankfort wrote his monograph; and we should like to know his opinion of them. However that may be, his other arguments sum-

[11] *Ibid.*, pp. 123–124.

marized here are in no way affected; for they rest on real resemblances of design as well as on analogies of style.

We must pass over other connections between the Egyptian and Mesopotamian civilizations, such as the recessed brick-building, which appears first in the mastabas of the First Egyptian Dynasty, and the cylinder seals. There are geographical reasons as well for looking from Egypt to Mesopotamia, for "it seems quite clear that [the new-comers] met the Egyptians near the shores of the Red Sea, where the Wadi Hamamat leads up to the Nile Valley; for it is on the Egyptian side of Wadi Hamamat that the earliest signs of their presence appear in late predynastic times. Again, the foreign elements are particularly connected with the First Dynasty, which originated in the adjacent part of the Nile Valley."[12] Obviously the Red Sea must have been crossed; but we know from the Gebel-el-Arak knife handle that the foreigners had ships; and Mr. Frankfort publishes some most interesting new evidence bearing on this point. On some pots of the time of Gudea of Lagash (about B. C. 2500 according to Dr. Langdon) there is represented a design consisting of a rather conventionalized ship and a long-legged bird standing on it and pecking at a fish. This design appears to have had a long history in Mesopotamia, for on the vase of Gudea it is somewhat "degenerate." Now the same design appears on two, and only two, prehistoric Egyptian vases! "We have to account for the remarkable fact that two designs, apparently unconnected—a special type of boat [foreign to Egypt] and a bird on a fish—appear but twice on the predynastic pottery and both times together. And, more striking still, exactly the same designs appear combined on the Babylonian vases."[13] Mr. Frankfort is surely justified in concluding "that this very type of boat was used by the Sumerianized foreigners who already in the end of the predynastic period influenced Egyptian art, as is conclusively shown by the decoration of the ivory knife-handles and the slate palettes."

Arabia as the Birthplace of Civilization

We will now drop our pilot and set sail alone on the dangerous seas of pure speculation. We have seen that the Sumerians probably came from the south and that they did not come from India. We have seen that an Asiatic influence which appears to be Sumerian influenced the early art of Egypt. Is it possible to find a common source for both Sumerians and what has hitherto been regarded as direct Mesopotamian influence on Egypt? Were the Sumerians driven from some now barren region of southern Arabia by the same

[12] *Ibid.*, p. 137.
[13] *Ibid.*, p. 141.

cause as that which at an earlier period had driven (as is conjectured) the People of the Painted Pottery from Susa to the land of the Two Rivers?[14] Did some of these Sumerian nomads settle in the Euphrates Valley, and others in the Valley of the Nile? It is not necessary to assume that both parts of this hypothesis must be right or both wrong. One alone may be correct.

It is a priori quite probable that the Sumerians originally inhabited some part of southern Arabia; there is hardly any other place left from which they could have come. But that southern Arabia rather than Mesopotamia was the source of the foreign influence in Egypt is a far more speculative assumption. Nevertheless a theory that explains two events by a single cause seems worth considering. The force of the argument from climate seems to be very strong; we know that deserts must have become drier since the Ice Age; we may even go further and say that during part of the Ice Age the deserts of Asia and Africa must have been preëminently habitable grasslands. They would hardly have been avoided by primitive man, whether he was a hunter or a nomadic herdsman. A relatively slight decrease in rainfall would suffice to turn the grassland into desert and drive the wanderers down to well-watered valleys. Such causes may have operated in Africa. They may have caused the first peopling of Egypt and the gradual dispersion of the neolithic peoples along the western margin of Europe. They may also have driven the Central Asiatic nomads down to the plains of China. But with these vast earlier movements we are not now concerned.

Is there any new direct evidence of an early Sumerian civilization in southern Arabia? As yet there is not; that is one of the few remaining regions of the world not yet explored. Not only have no archeological excavations been made there, but, except for one or two rapid reconnaissances, no European traveler has ever been there. It is possible that in Yemen, Hadhramaut, or Oman there exist undiscovered mounds like those recently discovered in the valley of the Indus. Indeed, if such can be found in India in 1924, unsuspected after more than 150 years of British occupation and many years of official archeology, what may we not hope to find in these vast unexplored territories? There is, indeed, a slight indication—it is almost too slight to be called evidence—which favors part of our theory, and it comes from the latest traveler who has penetrated into southern Arabia, Major Cheesman. Describing his visit to Jabrin (latitude 23° 18′ 6″, longitude 48° 54′ 10″) in 1923, Major Cheesman makes some interesting remarks about the Al Murra, the present inhabitants of that oasis. They live entirely in tents (there are no buildings there); they speak Arabic, but only in addition to their native tongue; and until two years before his visit they were pagans.

[14] *Ibid.*, p. 89.

Their enemies, the Awamir, who roam over the desert to the south, are said to speak a different language, described by the Al Murra as "a series of grunts." Major Cheesman says: "The Al Murra type of face reminds me of features to be seen on early Sumerian sculptures. It is not unreasonable to suppose that they are the remnants of this, the earliest civilization. The conquests and passing of nations on the trade routes would leave them unaffected and unchanged in the fastnesses of their desert stronghold."[15]

In one respect the hypothesis of early civilization in southern Arabia explains the foreign influence in early Egypt better than an assumed direct connection with Mesopotamia. This influence was ephemeral; it ceased altogether in later times when on a priori grounds one would have expected it to have increased, with the development of shipping and maritime trade. The pictures of ships of Mesopotamian type disappear after the First Egyptian Dynasty. Whether, however, the foreign influence in Egypt, which is a *fact*, came direct from Mesopotamia or from some undiscovered proto-Sumerian source in Arabia, it is reasonable to infer the existence of some such civilization and to hope for early confirmation of its existence.[16] A distinguished American Egyptologist said to the writer more than ten years ago that excavation in the Yemen was one of the few "plums" still left unpicked by archeologists. He spoke hopefully, but soon afterward the Great War destroyed what little hopes we had of searching for the birthplace of civilization.

[15] R. E. Cheesman: The Deserts of Jafura and Jabrin, *Geogr. Journ.*, Vol. 65, 1925, pp. 112–141; reference on p. 125.

[16] *Ibid.*, p. 140.

RAILROAD PROGRESS IN COLOMBIA

Raye R. Platt

THE west coast republics of South America are in that youthful stage of development which is characterized by rapid encroachments on the frontier in many widely separated regions. Even in a country whose physiography offers no great problems the building of railroads can hardly be kept in pace with such development. In the case of western South America there is the barrier of the Andes. Not only do the Andes north of Chile divide all the republics into two distinct regions, which face in opposite directions toward the foreign market, but there are lesser, yet nevertheless important, physiographic and climatic barriers within these larger divisions. Each district looking for a foreign market in which to sell its products seeks the shortest route to an ocean port. This is the dominant factor in South American railroad development.

The Intercontinental Railway

Reference may here be made to the progress in construction of the Intercontinental Railway. The Intercontinental Railway Commission met at Washington, December 4, 1890. At a series of meetings, of which this was the first, the commission, composed of representatives from eleven American governments, formulated plans for survey of a proposed route for a Pan-American Railway system. Its purpose, as set forth at the first meeting of the commission, was to foster "the development of cordial relations between the nations and the growth of material interests."

The first enthusiasm for the project has long since died down. Nevertheless, from time to time, as, in the slow but steady growth of the railway systems of South and Central America, new sections of railroad are completed that cover or approximate the route proposed for the Intercontinental Railway and its branch lines, statements appear that so many more miles of the Intercontinental Railway have been constructed. Such statements are not only erroneous *per se;* they obscure the real and highly interesting geographic and economic reasons for the railroads of South and Central America as they are now and also the reasons for the projects in hand to extend existing lines and systems. In no case have these railroads been planned with any purpose of carrying out the ideals of the Intercontinental Railway Commission. In every case they have been built

in response to the demand of the region concerned for an outlet for its increasing production.

A route by rail from New York to Buenos Aires and intermediate points in the Hispanic-American republics is, to be sure, not altogether out of question. Approximately 70 per cent of the 10,228 miles of route estimated by the commission is now covered by various systems, and to travel by rail from New York to Buenos Aires (with many changes, of course, on account of variations in gauge) is a possibility of the not too far distant future. But if the constantly narrowing gaps are ever completely closed, especially at international boundaries, it will be because of economic demands and political expediency.

While it is true that there is a steadily-increasing exchange of products between Chile and the Argentine Republic and between the Argentine Republic and Brazil[1] there is little commercial interchange among the west coast republics, and there are no international railways with the exception of the three routes from La Paz to the Pacific. None of these three routes was constructed to serve the needs of local interchange. Their *raison d'être* is to give to Bolivia an outlet to the coast.

International Railways of Central America

By way of contrast we may note the state of affairs in Central America. The International Railways of Central America, a company reorganized in 1921 from the Guatemala Railway Company, has merged under its control the majority of the principal railroads of Central America. It is planned to extend and link up existing lines so as to form a main line connecting all of the Central American capitals and to build branch lines to the important mineral and agricultural districts and the principal ports.[2]

The feasibility of the plan as regards Guatemala, Honduras, Nicaragua, Salvador, and Costa Rica[3] lies in the fact that these states constitute something of a geographic and economic unit. No important physiographic barriers separate them; and their principal products, which are agricultural, seek the same market and are largely handled by the same companies. The community of interests among these states, which has no counterpart elsewhere in Hispanic-America, is further evidenced by their frequent attempts to form a confederation.

[1] W. L. Schurz: International Communications in South America, *Foreign Affairs*, Vol. 3, 1924–25, pp. 624–636.

[2] W. R. Long: Railways of Central America and the West Indies, *U. S. Dept. of Commerce, Trade Promotion Ser. No. 5*, Washington, 1925.

[3] Ultimate extension is planned through Panama to Colombia. In Panama, however, the only piece of constructed road which it will be possible to use is a short section of the Chiriquí Railroad, and the extension is not to be expected in the immediate future.

The Problem in Colombia

In Colombia not only the economic development of the country but the realization of a state of complete national solidarity wait upon the establishment of an adequate system of transportation and communication. To satisfy even her most pressing economic needs Colombia faces a vastly larger program and more difficult problem of railway construction than any of the other west coast republics. In the other countries, inasmuch as their chief productive areas are still within comparatively easy reach of coastal ports, short railroads running down to the nearest roadstead form, with the coastwise shipping, a fairly satisfactory system of transportation within the countries themselves and to the foreign market. Such, however, is not the case with Colombia.

To understand the transportation needs and the problems of railroad construction in Colombia it is necessary to have in mind her outstanding physiographic features and her peculiar political make-up. In the neighborhood of Pasto the Andes, which, south of the Colombia-Ecuador boundary, have narrowed into a single range, divide into three ranges, the Western, Central, and Eastern cordilleras. These cordilleras divide the country into what may be roughly described as a series of strips running in a general north-and-south direction and separated by mountain barriers which offer serious obstacles to intercommunication. Between the Western and Central cordilleras and between the Central and Eastern, respectively, flow the Cauca and Magdalena Rivers. North of the northern end of the Central Cordillera these two rivers unite and flow as one to the Caribbean Sea. With the exception of the region around Pasto, which lies immediately north of the Colombia-Ecuador boundary and drains into the Pacific Ocean by the Patía River, and the Cúcuta region which lies in the drainage basin of Lake Maracaibo, the people of Colombia live in the drainage basins of these two great rivers and their tributaries. On a plateau high up on the western flank of the Eastern Cordillera is Bogotá, the capital of the republic, often described as the most isolated national capital in the world, completely shut off by distance and by natural barriers from the other settled districts of the country and by hundreds of miles from either ocean.

The Cauca and Magdalena Rivers

Neither the Cauca nor the Magdalena is navigable throughout. Impassable rapids divide the Magdalena into two sections navigable by river boats of light draught and break up the Cauca into several such navigable stretches. Around these rapids passengers and freight must be portaged by pack train or, as is the case between the Upper and Lower Magdalena, by a short railroad built for the purpose.

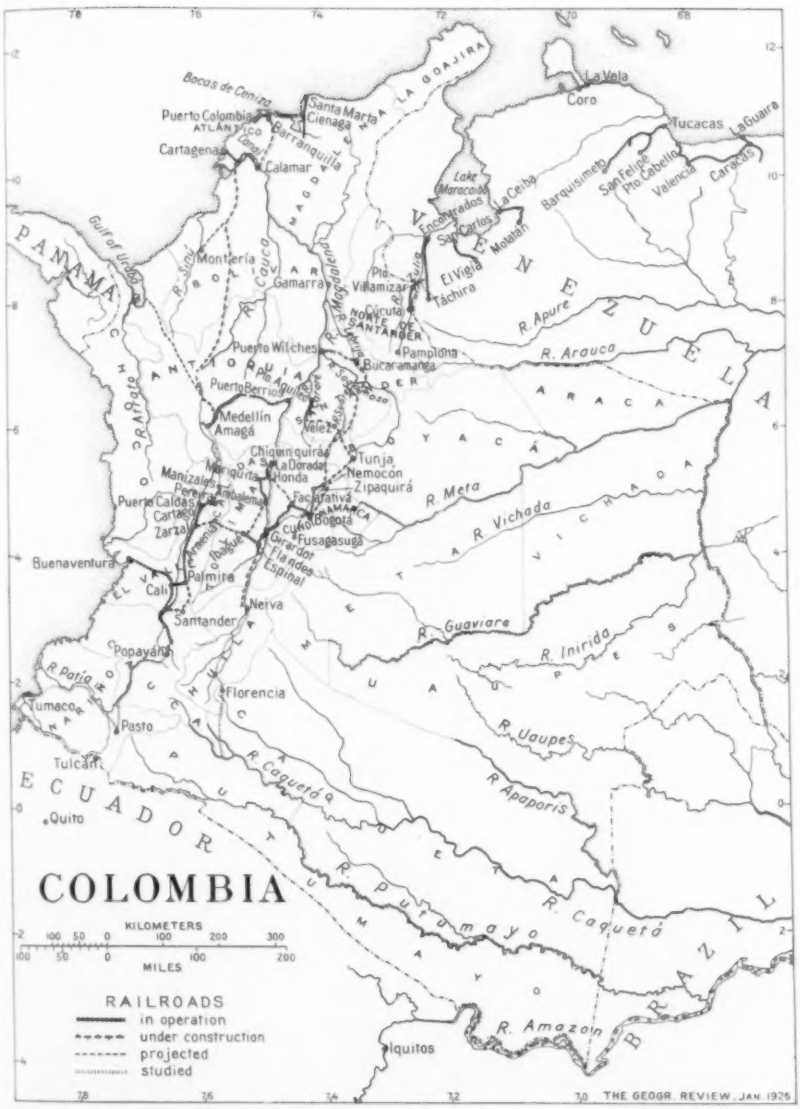

FIG. 1—Map showing the railroads of Colombia. Scale 1:12,500,000.

Navigation on these rivers also suffers a seasonal check. The Federal government is giving serious attention to a study of means of improving the navigability of the Magdalena,[4] and it is probable that in time a channel will be cleared at the mouth of the river to enable ocean steamers to come into Barranquilla and perhaps to ports at some distance up the lower river.

[4] See note in the record section of this number of the *Geogr. Rev.*

However, even if the Magdalena and Cauca were navigable throughout their length and at all seasons, and apart from the general question of river versus railway transportation, communication in these basins would still present problems. In general the principal productive and populated districts are located not in the tropical or semitropical valley floors of these rivers but in the many fertile and temperate upland plateaus which flank the valleys, for instance the Sabana de Bogotá, at over 8000 feet above sea level, in which is located the capital of the republic. The outstanding exception is the famous Cauca valley; but this is on the upper course of the Cauca River and lies at an average elevation of 3000 feet.

The building of railroads down from the plateaus to the river ports is in itself a difficult problem, not only because of the great steepness of the mountain sides which flank the main valleys, but because the plateaus are in most cases shut off by spurs and ridges of the main cordillera. The problem of constructing the connection over the crest of the Central Cordillera between the two sections now in operation of the railroad from Medellín to Puerto Berrios has not yet been solved. The Girardot Railway, by which the Sabana de Bogotá is connected with the Upper Magdalena, climbs approximately 8000 feet in the 132 kilometers of its length over half of which is through a confused mass of foothills and over two fairly well-defined secondary ridges which are parallel to the river.

The Present Program of Railway Construction

The program of railway construction now under way in Colombia falls into three divisions, apparently in the following order of importance: (1) The building of those railroads necessary to satisfy the most urgent needs for transportation between the principal productive areas and ocean ports; (2) the completion of a through rail route from the capital either to the Pacific or to the Atlantic Ocean; (3) the building of railroads that may serve as links between the capital and the outlying districts now having no adequate connection with the main body of the country and may at the same time afford those districts a satisfactory outlet for their products.

When the surveys were made for the Intercontinental Railway (1891–1894) there were in operation in Colombia only about 365 kilometers of railroad, divided among 10 short lines constructed to serve purely local needs. Approximately 1150 kilometers have been built since that time, and about 1200 kilometers more are involved in the building of new lines and the extension of old ones on which work is now being actively pushed. Such is the relative position of many of the districts for which the present construction program will afford outlets that, when the program is completed, practically the

whole route proposed for the main and branch lines of the Colombian section of the Intercontinental Railway will be covered, except for the extensions to the international boundaries which at the present at least would serve no economic purpose and would be of but doubtful strategic value.

Between the Western and Central Cordilleras

It is now a matter of only a few years at most before the basin of the Cauca River, the longitudinal strip between the Western and Central cordilleras, will be remarkably well served with railroads. When the Intercontinental Railway survey was made the only railroads serving this section were about 40 kilometers in operation on the Pacific Railway from Buenaventura toward Cali and about 50 kilometers of the Antioquia Railway from Puerto Berrios toward Medellín. Now approximately 770 kilometers are in operation in this section, and approximately 400 kilometers more are in what may be described as a state of actual construction. Nearly 800 kilometers more are in project, as distinguished from routes merely studied or proposed.

The Pacific Railway

Most important of the lines in this region, and probably the most important line in the republic, is the Pacific Railway which connects the rich Cauca Valley with the Pacific port of Buenaventura and which now has 481 kilometers of track in service. The 347-kilometer Buenaventura-Cali and Cali-Cartago sections are completed as well as 120 kilometers of the 160-kilometer Cali-Popayán section. Studies have been made for the extension of the line from Popayán to Pasto, by way of the valley of the Patía River, with Tumaco, its natural port on the Pacific. Pasto is important not only as a center of a large agricultural region and the *locale* of several manufactures (among them the well-known Pasto varnish) but also as a distributing center for foreign goods to a large section of southern Colombia and northern Ecuador.

Construction work is being carried on in all of the projected extensions to the Pacific Railway. Most important of these is the Zarzal-Armenia section of the proposed extension of the Pacific Railway across the Central Cordillera to Ibagué which, by connecting at Ibagué with the Tolima Railway, would provide a through route by rail from Bogotá to the Pacific Ocean. This connection was proposed but not surveyed by the Intercontinental Railway Commission. The connection with the main line of the Pacific Railway is to be made, however, not at Cartago, as planned by the Commission, but at Zarzal. No route has yet been definitely accepted

for the Armenia-Ibagué section of this line; but the Armenia-Zarzal section alone, 73 kilometers in length, will do important service not only in providing an outlet for the agricultural products of the Armenia district itself but also in shortening the difficult pack-train route over the Quindío Trail by which a large part of the coffee from the famous Quindío coffee region is brought down to the Pacific Railway.

Railways in Caldas

North of the Pacific Railway and connecting with it at Cartago is the Caldas Railway, which is under construction by the Department of Caldas and is destined to connect Manizales (capital of the Department and second only to Medellín as a market for gold, coffee, cacao, and cattle) with the Pacific Railway and the Cauca River. This road has now 70 kilometers in operation from Puerto Caldas on the Cauca River through Cartago and northward toward Manizales. Construction is being pushed on the additional 43 kilometers between Manizales and the end of present construction. Manizales is already afforded freight connection with the river traffic of the Upper and Lower Magdalena by means of an aerial cableway to Mariquita on the Dorada Railway. This cableway is 73 kilometers in length—the longest of its kind in the world. It is owned and operated by a private firm, but the Federal government now proposes to erect a similar cableway from Manizales across the Western Cordillera and through the gold and platinum regions of the Choco to some point on the Pacific. The government is giving much consideration to the feasibility of aerial cableways to serve districts where the cost of railroad construction is, for the present at least, prohibitive. An English authority on aerial cableway construction has been engaged to act in an advisory and exploratory capacity to the Department of Public Works. The aerial cableway serves its purpose particularly well when the commodity to be carried is precious metal or other products whose value is high in comparison with their bulk and weight.

Railways in Antioquia and Bolívar

In the Department of Antioquia construction has been actively resumed on the Amagá Railway which is now in operation between Medellín and Amagá—a distance of about 50 kilometers. The immediate project is concerned only with the completion of the 81-kilometer line from Medellín to the Cauca River where connection can be made with the Pacific Railway by river boat to Puerto Caldas and thence by the Caldas Railway to Cartago or by river boat direct to Cali. Further plans provide for the extension of the road from Amagá to Manizales, affording direct rail connection between Medellín and Buenaventura. The Antioquia Railway from Medellín to

Puerto Berrios on the Lower Magdalena is now completed except for a break of about 15 kilometers at La Quiebra, a crest in the main range of the Central Cordillera which presents a problem of construction not yet solved. Either a rack railway or a tunnel will be necessary. Meanwhile the road is being operated in two sections which together total 180 kilometers, and transportation across the gap between these two sections is by wagon or automobile. When it is realized that practically all of the products of the Department of Antioquia, richest, in point of production at least, of all the departments of the republic, must find their way to the market over this route, it will be seen how pressing is the need of completing this gap.

Plans have long been considered for a railroad from Medellín to the Gulf of Urabá (Darién), and three routes have been studied at various times. In 1905 an American was granted a contract for the construction of the road. After the work of establishing a new port on the gulf had been started and one kilometer of track had been laid into the adjacent swamps, work was suspended, and in 1909 the contract was declared void. It is understood that a contract has again been let for the survey and construction of the road. It would seem that the reason for constructing such a railroad can only be strategic. In fact it is difficult to conceive of even any strategic purpose that it would serve. To be sure it will afford a means of communication between this isolated section and the commercial and administrative centers of the republic, but the region traversed is practically unpopulated. Although it might have been an advantage to the republic to have had a road across this section and on into Panama before the separation of Panama, it would seem that the need for it no longer exists. The line will traverse a section of Antioquia which promises to be of considerable importance in the production of oil, but the logical outlet for that section is rather by a line to Cartagena crossing the Sinú River oil region of the Department of Bolívar en route.

The Department of Bolívar has studied a route for a railroad from Cartagena to Montería on the Sinú River with the idea of connecting with the proposed Medellín-Gulf of Urabá line. The Ministry of Public Works of the Federal government has had a technical commission surveying a route for a railroad from Cartagena to Medellín, and it is reported that construction work has been started on the line. This road, which stands high on the list of railroads which are to be pushed to early completion, will form a link in the through route from Cartagena to Popayán in which the Federal government is much interested.

All of the railroads constructed and projected in this section are of yard gauge—a uniformity worthy of note in South American railroad construction.

Between the Central and Eastern Cordilleras

At the time of the Intercontinental Railway surveys, in all of this great drainage basin of the Magdalena River, only five short railroad lines, totaling about 160 kilometers, were in operation. In this total is included the 50 kilometers then constructed from Puerto Berrios toward Medellín on the Antioquia Railway, which is of practically no importance to the section. The others, which can scarcely be described as serving even local needs, were the Sabana Railway, 41 kilometers in length and extending from Bogotá across the Sabana de Bogotá to Facatativá, about 40 kilometers of the Girardot Railway from Girardot on the Upper Magdalena up the Bogotá River to the mouth of the Apulo River, a few kilometers from Bogotá to the suburb of Chapinero on the Northern Railway, and a short section of the Dorada Railway planned to connect the river boat traffic of the Upper and Lower Magdalena. Approximately 390 kilometers have been built since that time. In view of the great need of railroads in this section, this increase for a thirty-year period is surprisingly insignificant. Such lines as have been built, however, have been located to good purpose, and the projects upon which work is now being actively carried on will add over 800 kilometers to the present total and practically solve the transportation problem of the region as far as main lines are concerned.

Bogotá's Rail Connections

Most important of the railroads completed since the surveys for the Intercontinental Railway is the Girardot Railway, which has been extended to meet the Sabana Railway at Facatativá instead of continuing up the Bogotá River as originally planned. By the completion of this line of approximately 132 kilometers Bogotá is afforded complete rail connection with the river boat traffic of the Upper Magdalena, although the difference in gauge between the two railroads (the Girardot Railway is of yard gauge and the Sabana of meter) necessitates the transfer of passengers and freight at Facatativá. The completion of this railroad and the Dorada Railway, which has been extended at both ends until it now forms a rail portage 119 kilometers in length completely around the rapids between the navigable upper and lower sections of the Magdalena, has almost completely eliminated the pack train from the Bogotá-Barranquilla route and has greatly increased the traffic on the Upper Magdalena. Practically all of the traffic, not only from the Bogotá district but also from all the adjacent districts, whose easiest route to the Magdalena is by way of the Sabana de Bogotá now comes down to the Upper Magdalena by the Sabana and Girardot railways, whereas it was formerly carried over difficult pack train routes between the Bogotá

district and points on the Lower Magdalena. The labor of bringing to Bogotá, by these long pack train routes from the Lower Magdalena, all of the foreign manufactures demanded by a city which even in the last decade of the past century had a population of approximately 125,000, is almost inconceivable.

Even now the transporting of freight to and from Bogotá to the Caribbean is laborious and costly, and the freight charges on many articles of foreign manufacture from the factory to Bogotá equals or exceeds the original cost of the article. An appreciable cut in this cost will be made when the canalization of the Bocas de Ceniza at the mouth of the Magdalena River is completed. At present, to carry a piece of merchandise from the steamship to Bogotá involves six transfers: from the wharf at Puerto Colombia to Barranquilla by rail, Barranquilla to La Dorada by river boat, La Dorada to Ambalema by the Dorada Railway, Ambalema to Girardot by river boat, Girardot to Facatativá by the Girardot Railway, Facatativá to Bogotá by the Sabana Railway.

Although numerous plans have been proposed for a railroad to connect Bogotá with a Caribbean port, no such line is in project and the only possibility of such a route lies in the completion of the Northeastern and Cararé railways to Puerto Berrios and the Medellín-Cartagena line. A rail route from Bogotá to Cartagena through Medellín would thus be afforded. The most immediate prospect for a rail route from Bogotá to an ocean port lies in the completion of the Zarzal-Ibagué connection between the Pacific and Tolima railways. The Tolima Railway, 79 kilometers in length, from Flandes, on the Upper Magdalena opposite Girardot, to Ibagué has shortened the pack train route over the Quindío Pass in the Central Cordillera between Girardot and the Pacific Railway to approximately 246 kilometers, and many travelers to and from Bogotá now prefer this arduous but shorter trip to the Magdalena River route. The Zarzal-Armenia section of the Pacific Railway now under construction will cut off a further 73 kilometers. This route was proposed by the Intercontinental Railway Commission, but, inasmuch as it was planned only as a connecting link between Bogotá and the main line, the proposal was hardly practical at that time. Now, however, the opening of the Panama Canal has changed the situation by making Buenaventura easily accessible to the United States and Europe, and the Pacific route, although costly and difficult enough, will be far less expensive to complete than any other possible rail route from Bogotá to an ocean port.

Railways in Tolima

The contract has been let and work is in progress on a connecting link between Ambalema, the Upper Magdalena terminus of the

Dorada Railway, and a point near Ibagué on the Tolima Railway. This line of approximately 70 kilometers is comparatively easy of construction. It may delay completion of the Ibagué-Armenia section of the Pacific route, inasmuch as it can be argued that the agricultural districts of the southern part of the Department of Caldas and of the central and northern parts of the Department of Tolima will be sufficiently well served for the time being and that whatever funds are available should be used for such regions as are still completely lacking in railroad transportation.

From Espinal, on the Tolima Railway, the so-called Tolima-Huila-Caquetá Railway has been built 30 kilometers to the Saldaño River, and further construction is in progress. It is planned to extend this road through Neiva on the Upper Magdalena and thence to the head of navigation on the Caquetá River of the Amazon Basin. It will thus be an important factor in the development of an extensive region in the drainage basins of the Upper Magdalena and the Caquetá and Putumayo Rivers which is now being extensively explored for oil. The railroad will also be of considerable possible strategic value inasmuch as it will join to the main body of the republic what is now its most inaccessible territory. Much of this territory has long been in dispute with Brazil, Ecuador, and Peru[5]—a dispute which has only recently approached settlement by the Colombia-Ecuador boundary treaty of 1916 and the Brazil-Colombia-Peru treaty signed in Washington in February of last year but not yet ratified by all the countries concerned.

Routes East of the Magdalena

Colombia's greatest present need of railroads is in the territory between the Magdalena River and the main range of the Eastern Cordillera. In all this great region there is only one rail route to the Magdalena—the Bogotá-Girardot route discussed above. The northern part of the Department of Cundinamarca and all of the departments of Santander and Boyacá are completely lacking in railroads although, in potential agricultural and mineral resources, they are among the most important in the republic and contain some of its most densely-populated districts. Bogotá is the commercial center for all of Cundinamarca and Boyacá, and, except for short sections of railway radiating from Bogotá and a good motor road to Tunja, capital of Boyacá, all distribution of foreign manufactures and practically all transportation of products is by pack train by way of Bogotá. Bucaramanga, capital of the Department of Santander and center of one of the most important tobacco districts of Colombia

[5] R. R. Platt: Present Status of International Boundaries in South America, *Geogr. Rev.*, Vol. 14, 1924, pp. 622–638.

and of an important coffee district which now annually produces over 100,000 bags of coffee, ships all exports to and receives all imports from the Lower Magdalena by boat and small steamer on the Sogamoso and Lebrija Rivers or by pack train.

A route has been studied for a railroad along the valley of the Upper Magdalena from Girardot to Beltrán on the opposite bank of the river from Ambalema. As far as the cost of construction is concerned this route would be the least expensive means of affording the Bogotá district direct rail connection with the Lower Magdalena; but it has been abandoned, temporarily at least, in favor of three roads now under construction each of which will not only give Bogotá a direct route to the Lower Magdalena but will also give the departments of Boyacá and Santander and the northern part of Cundinamarca railroad connection with the Lower Magdalena and with the national capital.

Most important of the three lines is the Northern Railway which is now operated for 62 kilometers from Bogotá to Nemocón through Zipaquirá. The Bogotá-Zipaquirá section of this line has always been profitable, and the extension to Nemocón, the center of an extensive coal region, affords access to a source of cheap fuel. The road is now being carried northward to Chiquinquirá. In June, 1925, nearly 5000 laborers were engaged on the construction of the 88-kilometer Nemocón-Chiquinquirá section, and 54 kilometers of the grading had been finished and 21 kilometers of track laid. The section from Chiquinquirá to Bucaramanga will be about 256 kilometers in length and is comparatively easy of construction. A considerable section of it will run through the fertile and well-populated valley of the Suarez River. Construction on this section, however, will probably not be started until the so-called Northern Central Railway, which is now building from Puerto Wilches on the Lower Magdalena toward Bucaramanga, is completed.

The Northern Central has been under consideration for many years. Construction had been started on the Puerto Wilches end when the Intercontinental Railway survey was made. Twelve kilometers of track were laid at that time, and the whole project was abandoned because of the difficulty of carrying out even the preliminary survey through 30 or 40 miles of virgin forest. Now, however, a route has been chosen along the watershed between the Sogamoso and Paturía Rivers; the survey has been made, and construction is once more under way. In June, 1925, grading had been completed on 61 kilometers of the total 134 kilometers which the line will cover, and 4000 laborers were employed on the work. When the whole system from Bogotá to Puerto Wilches is completed, Bogotá will have a through rail route, of uniform meter gauge and approximately 540 kilometers in length, to the Lower Magdalena, which, in addition to eliminating

the transfer incident to the present route by rail and river boat to the same point, will be over 200 kilometers shorter.

Chiquinquirá, in the Department of Boyacá, is even now, because of comparatively easy access by pack train to the Nemocón terminus of the Northern Railway, a distributing and market center for a large district in Cundinamarca, Boyacá, and Santander; and it would seem that the least expensive way of affording rail connection to Tunja, capital of Boyacá, and other districts to the east of the route of the Northern Railway in both Cundinamarca and Boyacá would be by means of branch lines to the main line of the Northern Railway. Nevertheless, construction is now under way on two roads which will give Tunja direct connection with Bogotá and with the Lower Magdalena. The first of these, the Northeastern Railway, is being built with Belgian capital and by Belgian engineers and is expected to be open to traffic by the end of 1926. Connection will be had with the Northern Railway at Suesca, a short distance northeast of Nemocón, by a branch from the Northern Railway which has already been constructed. At Tunja the Northeastern Railway will connect with the Cararé Railway, which is now building toward Tunja from Puerto Aquileo, the head of steamer navigation on the Cararé River. This line will run through Velez and probably cross the Northern Railway at Moniquirá.

A third railway from Bogotá to the Lower Magdalena is being built entirely within the Department of Cundinamarca by a route which has now been chosen from the three routes studied for extending the Cundinamarca Railway, as the Sabana Railway and its projected extensions are called, to the Magdalena. The first of these to be considered was a line from Facatativá to Beltrán where connection could be made with the Dorada Railway. No work has been done on this route. A second proposed extension of the Sabana Railway, 228 kilometers in length from Facatativá to Puerto Niño (a point on the Lower Magdalena about halfway between Dorada and Puerto Berrios) was surveyed in 1917, and approximately 14 kilometers of grading were done from Facatativá. No further work has been done on this road. In 1879 a concession was granted to an American for a railroad from Honda to the Sabana de Bogotá along the route of the old pack trail. Four kilometers of track were laid, and a locomotive was imported from the United States and placed on it. Financial difficulties and the death of the concessionaire put an end to the enterprise. The remains of the locomotive are still a landmark on the trail from Honda to Facatativá. Now work has been resumed on this road, and nine kilometers from Facatativá to La Tribuna have recently been opened to traffic. The total length of the line will be about 130 kilometers. This line will be a formidable rival of the Girardot Railway inasmuch as it will be of the same gauge as the Sabana Railway (one meter),

whereas the Girardot Railway is now of yard gauge, and will also be about 175 kilometers shorter than the present route from Bogotá to Honda by way of Girardot and Ambalema.

Another railroad, which now serves only purely local needs in the Bogotá district but which is in immediate prospect of considerable extension and will probably be eventually extended to the Upper Magdalena, is the Southern Railway. It was originally planned that this line should run only from Bogotá to the coal region around Tequendama at the point where the Bogotá River cuts through the rim of hills enclosing the Sabana de Bogotá on the west. It has, however, been extended 30 kilometers along a narrow southwesterly arm of the Sabana to Sibaté, and a six-kilometer branch has been built to El Charquito on the Bogotá River. At present this road carries such traffic as comes up to the Sabana by way of Tequendama and a considerable portion of the traffic to and from Fusagasugá, center of an important coffee region three or four hours' journey by pack train from Sibaté. The government has now decreed the construction of the Sibaté Fusagasugá extension of the line, and the work of grading is in progress. Plans have been discussed for the eventual extension of this line to Girardot by way of the Sumapáz River.

The Cúcuta Region

The important agricultural district of which Cúcuta, capital of the Department of Norte de Santander, is the commercial center is completely separated from the basin of the Magdalena River by the Eastern Cordillera and belongs physiographically to the Lake Maracaibo basin. It looks to the Lake Maracaibo ports. From Bucaramanga or from points on the Lower Magdalena the district can be reached only by difficult and little-used trails over the Eastern Cordillera. The Cúcuta Railway, 71 kilometers in length, from Cúcuta to Puerto Villamizar, was in operation when the surveys for the Intercontinental Railway were made, its object being to connect Cúcuta with the river boat traffic on the Zulia River and thus provide a rail and water route to Lake Maracaibo ports.

It was proposed by the Intercontinental Survey Commission that a railroad should be built from a point on the Magdalena River opposite Puerto Berrios through Bucaramanga and Cúcuta and on into Venezuela, thus affording an international route between Venezuela and Colombia and at the same time giving Cúcuta access to the Magdalena. There has been no action on this proposal. Routes from points farther north on the Magdalena to Cúcuta have been studied, but in each instance the cost of construction has been found prohibitive, at least for the present. In 1897 a short line, slightly over 16 kilometers in length, was opened between Cúcuta and the Tachirá River,

a tributary of the Zulia River which forms a part of the Venezuela-Colombia boundary. In 1906, however, the Venezuela government closed the Zulia River to traffic from Colombia, and interest was revived in a railroad from the Magdalena. But in 1907 the river was again opened, and now the Cúcuta Railway and the Tachirá Railway in Venezuela are to be connected by short extensions to both lines. Thus for the time being the need for a transportation outlet for Cúcuta through Colombia has been eliminated.

However, in spite of the fact that the Colombia-Venezuela boundary difficulties have now been settled, there is always a possibility that other difficulties may arise, whether international or only local in scope, which might again shut off Cúcuta from Lake Maracaibo. This eventuality, as well as the fact that Cúcuta is so completely separated from the main body of the country and so definitely allied physiographically and economically with the Venezuelan section of the Lake Maracaibo basin, makes it appear a matter of policy that there should be a rail connection between the district and either Bogotá or the Magdalena. An aerial freight cable from Cúcuta to Gamarra on the Lower Magdalena is now under construction by the Department of Public Works of the Federal government. It will hardly satisfy the real need of the Cúcuta district, which is not so much for a freight line as a line of intercommunication with other parts of the republic.

Railroads of the Caribbean Coast

Three railroads, which do not fall in any of the above classifications and which serve mainly local needs, are the Barranquilla Railway, the Cartagena Railway, and the Santa Marta Railway. The first of these is a line 27 kilometers in length and of 3½ foot gauge which connects Barranquilla, the terminus of traffic on the Lower Magdalena, with the port of Puerto Colombia. It seems likely that the use of this line will be greatly diminished if not completely eliminated when the canalization of the Bocas de Ceniza is completed and ocean steamers are able to come directly to Barranquilla. The Cartagena Railroad, from Calamar on the Lower Magdalena to the seaport of Cartagena, was built to carry the traffic which had up to the time of the War of Independence gone through the Dique—a canal cut by the Spaniards in 1570 and after the War of Independence allowed to fall into such a state of decay that it was no longer navigable. The railroad is 105 kilometers in length and of yard gauge. It has served to build up Cartagena, which after the war fell from a population of 35,000 to one of 3000, to a present estimated population of over 50,000; but, with the improvement of the harbor at Puerto Colombia and the construction of the Barranquilla Railway, it looks

as if Cartagena would be eliminated from any part in the Magdalena River transportation route and as if her future would depend upon the construction of the Cartagena-Medellín railroad and the development of such oil fields in the departments of Antioquia and Bolívar as will find their natural outlet through Cartagena.

The Santa Marta Railway, which extends southward 96 kilometers from the town and harbor of Santa Marta, depends for its revenues mainly upon the banana trade of the district it serves. Connection with Barranquilla is afforded by means of a short branch line from Cienaga to Puerto Viejo and by small steamers running through the inland channel between the two points. Sixty kilometers of this road were in operation at the time of the Intercontinental Railway surveys. Extensions were then and have since been proposed to various points on the Lower Magdalena. It is highly improbable, however, that such extensions will ever be built, inasmuch as two lines are already competing for the trade between the seacoast and the river. The road is of yard gauge.

The solution of Colombia's transportation problem lies in the building of a carefully planned system of trunk and branch railway lines; and the present program of construction, although subject perhaps to considerable modification, seems well planned to serve the country's needs. With the present improvement in the financial condition of the country, due to the impetus in the exploitation of agricultural and mineral resources as well as to the payments now being made by the United States in settlement of the Panama Canal matter, it is probable that the extensive program of railroad construction now being pushed by the Federal and Departmental governments will in large part be carried out.

ICE CAP AND SEA ICE IN NORTH GREENLAND

Lauge Koch

THE Bicentenary Expedition to Northern Greenland had for its main objective investigation and survey in Peary Land, the most inaccessible part of Greenland.[1] It was proposed to make the outward journey along the coast and the return, late in summer when travel on the sea ice was impossible, over the inland ice. It was further planned to ascend the ice cap from the head of Independence Fjord and for mapping purposes to travel as near the coast as possible, i. e. along the edge of the ice cap. The plan was successfully carried through. Though we suffered a serious shortage of provisions we were on the other hand favored to an exceptional degree by fine weather, not being held back a single day by snowstorm or fog.

Traveling near the coast, however, is troublesome for various reasons. In the first place we had to cross the great, crevassed depressions in which the fiord glaciers head, a topography with good reason ill-famed since Peary's first journey. Apart from this we had constantly to travel up and down in very rough territory. On the other hand, a journey near the edge of the ice cap presented various advantages. Often we traveled at a positive temperature, which spared us the necessity of melting ice in order to get drinking water and thus from encroaching further on our small store of petroleum. During nearly the whole journey traveling was easy because the ice was firm and hard and in most places almost without snow. To this must be added another circumstance which we had at first feared, but which subsequently proved a great facility. Our traveling route took us across the great glaciers so near their termini that all the snow was melted, hence the crevasses, though large and difficult to traverse, were visible and not treacherously hidden by snow bridges.

The Ice Cap

In the course of time North Greenland has been traversed more often than any other part of the inland ice. As a result of Peary's crossings in 1892 and in 1895 we have three profiles of the ice cap. Unfortunately Peary's observations for altitude were few and inaccurate, but his descriptions, especially of the zone near the edge of the ice

[1] Cf. the note "Plan of the Bicentenary Expedition to the North of Greenland," *Geogr. Rev.*, Vol. 10, 1920, pp. 348–349.

cap, afford several good suggestions with regard to details. In 1912 Knud Rasmussen traveled in the same regions and got a particularly good profile, and again in 1917 for the region from St. George Fjord to Inglefield Land. My latest journey furnished definitive information concerning the glaciers that descend into the fiords, and the extent of the ice cap. Unfortunately the boiling point apparatus I carried with me did not work satisfactorily. My altitudinal determinations were based on three good aneroids, which were read off at all camps both on arrival and departure. Owing to the calm and settled weather during the whole journey, the errors caused by variations in the atmospheric pressure were reduced to a minimum. In this connection it may be mentioned that upon arrival at Kane Basin the displacement of zero was only between 15 and 30 meters.

I have elsewhere called attention to the fact that in North Greenland the surface of the ice cap is unusually low.[2] The 2000-meter contour occurs far up in the interior of the country and even outside the 1000-meter contour there are great areas covered by ice. As will be seen from Figure 1, the ice covers a series of plateaus; between them there are depressions, the outer parts of which form fiords, which can be traced far up into the ice cap. The heads of these depressions form a caldera with precipitous and much fissured sides. Something similar to this, though on a much smaller scale, was pointed out by Drygalski with regard to several glaciers in Greenland.

Floating Glacier Ice

In Figure 1 it will be seen that on the north coast of Greenland there are four glaciers, great parts of which float on the sea. The largest is that of Petermann Fjord; including the depression, this glacier has a length of no less than 200 kilometers, of which the outermost 40 kilometers float on the sea. The floating part of the glacier is very thin, the terminus being only from two to five meters high. It may easily be understood why Petermann Fjord was assumed to be a channel opening towards the southeast for, standing at the mouth of the fiord and looking back into it only a few kilometers from the terminus of the glacier, you can see neither land nor glacier ice. The same is the case with regard to Ryder's Glacier in Sherard Osborn Fjord, for the terminus of this glacier also is only a few meters high.

In the thick and old sea ice outside the glaciers in Nordenskiöld Fjord and Independence Fjord (Academy Glacier) there are several detached icebergs. They suggest that at least several times in every century, and this is especially the case in Independence Fjord, there is open water that enables the icebergs to float away. The floating

[2] Lauge Koch: Some New Features in the Physiography and Geology of Greenland, *Journ. of Geol.*, Vol. 31, 1923, pp. 42–65.

parts of these two glaciers are not composed of a homogeneous mass, as is the case in Petermann Fjord and Sherard Osborn Fjord, but only densely packed icebergs. In other words they are formed by regeneration, crevasses having fissured the entire glacier before they begin floating. The area of these few floating glaciers of northern Greenland is considerably less than that of the floating glaciers of the eastern coast.

Sikussak, a Form of Sea Ice

Sikussak is an Eskimo name meaning "very old ice." It was first used by Knud Rasmussen and Peter Freuchen in the report of the First Thule Expedition without any very clear definition. Later J. P. Koch described the same form occurring in Frederick Hyde Fjord as paleocrystic ice. After my journey in 1917, during which I had ample opportunity of observing the sikussak in both winter and summer phases, I assumed it to be a transition form between glacier ice and sea ice. During my journey in 1921 and 1922, however, it proved that everywhere there was a very sharp and easily perceptible line of demarcation between the floating glacier ice and sikussak, and finally there were gradual transitions between sikussak proper and the somewhat younger sea ice. This means that the sikussak was originally sea ice that has become rougher and rougher in the course of successive summers. After two to five years the ice has become quite fresh, and its structure is increasingly granular until it cannot be distinguished from glacier ice. The older the sikussak the rougher it is. Between several frozen fresh-water lakes rise walls of granulated ice, the height of which is about one meter. In the depressions in their surfaces snow accumulates in winter. In the summer the snow melts, but there is no outlet for the water from the lakes; and thus the winter snow, though through a melting process, enters as a component in the surface of the ice. The maximum thickness of the ice is most probably seven to eight meters.

Sikussak ice has only a limited geographical distribution. The largest area occurs in the central part of the north coast where all the fiords are filled with sikussak. Typical and very old sikussak is found in Frederick Hyde Fjord, in Bessels Fjord, and just north of the Humboldt Glacier. This ice is formed only in calm fiords. It helps to prevent the calving of icebergs from the glaciers and is the reason why they float on the sea. It is often difficult to distinguish floating sea ice from the sikussak. To be called sikussak the ice must be at least 25 years old.

Sea Ice Many Years Old

Sea ice that has existed for more than five years but less than 20 years is quite fresh, in some degree granulated, and tends to have a

rough surface. It occurs in Independence Fjord and in Hagen's Fjord, which are probably ice-free once or twice every century, along the southern part of the Humboldt Glacier where many stranded icebergs hold back the sea ice, and in the fiords east of Cape York where the current and the wind keep back the ice, and in which, as experience has shown, the ice breaks up only five or six times in the century. In the middle of the summer it is naturally very difficult to travel on this ice, especially about August 1; but by the middle of the month the lakes on both this and the sikussak are generally covered with ice and with the exercise of some caution may be crossed.

The Winter Ice

On the map (Fig. 1) is given the maximum limit of the winter ice in North Greenland. This limit may vary considerably from year to year, and in the heads of the fiords it is rather an uncommon thing for the ice to break up. Outside the land ice, at any rate in Melville Bay, there are great masses of very compact drift ice so firmly packed that it is very difficult to make out where the land ice sheet stops and the drift ice begins. A considerable part of the land ice remains the whole summer in Melville Bay, and I have observed that if there is not very much drift ice beyond, it often does not get detached until October, and thus the minimum of land ice in Melville Bay is not reached until about November 1.

Paleocrystic Ice

Since the middle of the last century Smith Sound-Robeson Channel has been the great highroad to the North Pole. This is due to the theories of the open Polar Sea that have called forth a whole literature and after Kane's and Hayes's expeditions for a long time kept alive the interest in these regions. The open Polar Sea proved to be nothing more than the open sea in the southern part of Kennedy Channel, where current and winds are particularly strong. After Hall's and Nares's expeditions all idea of an ice-free sea farther northward had to be abandoned, and it was during Nares's expedition that the term "paleocrystic ice" was introduced. It would take us too far afield to survey the discussion concerning this matter that followed upon Nares's and Greely's expeditions. Opinions differed much. Some adhered to the opinion that the ice blocks several meters high and resembling icebergs really were icebergs, whereas others maintained that they were the Polar ice that by freezing had reached a thickness of about 40 meters or even more. Peary was of opinion that the paleocrystic ice had been formed in the interior of calm bays and fiords, in other words that it was particularly well developed sikussak. The north coasts of Grant Land and Greenland are now so

well known that it can be definitely stated that no glaciers along these coasts produce icebergs. I can mention only one exception, namely two glaciers on Cannon Land a little to the west of the most northerly point of Greenland, where a few small icebergs are formed. The idea of icebergs from a hypothetical land north of Grant Land must temporarily be dismissed as long as we do not know anything about the existence of such a land, and in no places have I seen paleocrystic ice that supports the conjecture of such a land.

However, paleocrystic ice can be explained otherwise. Through Peary's attempts to reach the North Pole our knowledge of the sea ice north of Greenland was greatly increased. During his journeys he reached what he called the Big Lane and, having passed this lane which consisted of a system of leads with open water, soon drifted eastward. The Big Lane extends north to Grant Land in about latitude 84° 30′ N. and farther to the east almost to Cape Bridgman, but when the explorer has passed Cape Bridgman and travels along the east coast of Peary Land he will see that the ice changes. According to my conjecture all the ice that lies north of the Big Lane is drifting eastward into the Atlantic Ocean at considerable speed, whereas all the ice south of the Big Lane is pressed against the north coast of Greenland. The ice that drifts into the Atlantic is carried by the current along the east coast of Greenland and farther along round Cape Farewell and some distance up the west coast, where it gradually melts.

During my journey along the north coast of Greenland I several times observed in the leads a current running westward along the coast; its existence is also shown by the accumulation of ice masses. The ice north of Greenland in the regions south of the Big Lane is pressed southwards through Robeson Channel. The nearer we approach Robeson Channel, the more violent is the tension in the ice and the more do the ice sheets decrease in size. North of Peary Land the sheets may be a square kilometer in area, and the hummocks between them are generally not very high. North of Sherard Osborn Fjord the sheets increase considerably in size, and in the mouth of Robeson Channel the small sheets are commonly surrounded by huge screw walls.

While traveling on the ice sheets north of Greenland it happened over and over again that we had to pass long ridges reaching a height of ten meters or even more. These ridges may rise evenly with only slightly sloped flanks from the surface of the ice cap, but they may also be irregular and have more precipitous flanks, and all transition forms from the more regular ridges to quite young hummocks may be found. They must have originated by the collision of ice sheets with formation of hummocks. During the summer the sheets are constantly being pressed together, the hummocks partly melt, all the sharp

edges are rounded off, and in the autumn the two sheets freeze together. In the course of years the old hummock becomes more and more rounded, the snow forms layers around it and does not melt until the summer, and the result is an elevation in the ice that may be many meters thick. In the course of time the sheet drifts southward to-

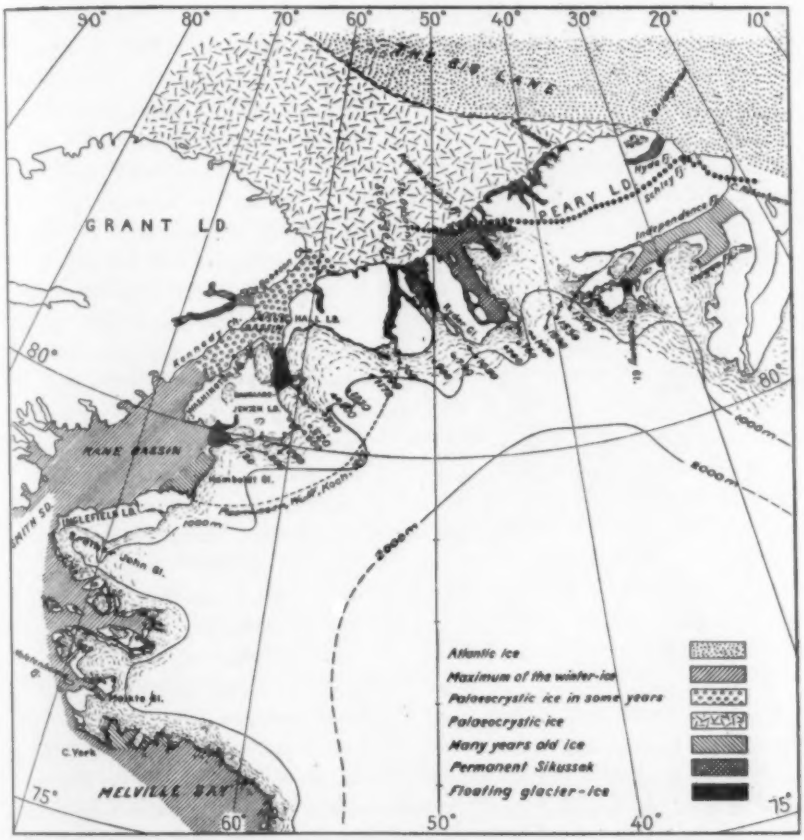

FIG. 1—Map showing the altitude of the ice cap of north Greenland and the types of ice off the coasts. The heavy dotted line shows the maximum limit of the ice in Peary Land during Pleistocene glaciation.

wards the mouth of Robeson Channel, the edges break off, the sheet becomes smaller and smaller, and at last only the thickest part of it is left, namely the original hummock, with a structure become granular just like that of glacier ice. There is hardly any doubt that 90 per cent or even more of the paleocrystic ice consists of such old sheets. From Robeson Channel the ice drifts southward through Kennedy Channel, and in some years ice occurs as far as Franklin Island in the middle of Kennedy Channel which forms a bulwark against its southerly advance. In other years the ice masses may

drift southwards, and open water may occur as far as latitude 82° N. The wind seems to be a great factor with regard to the extension of the ice; strong winds from the north clear not only Kennedy Channel but also make open water in Kane Basin, whereas frequent storms from the southwest hold back the ice. The struggle to reach the North Pole has been the history of good or bad ice conditions in Smith Sound-Robeson Channel; several expeditions did not even reach Kane Basin, whereas others with great difficulty succeeded in advancing along the coast through open water, and only a very few found entirely open sea as far as latitude 82° N. I learned this in 1917. The year before, the ice had extended as far as the middle of Kennedy Channel. In 1920 there must have been open water to latitude 82° N., since the next year I traveled on level new ice northwards through Robeson Channel. Next year the paleocrystic ice penetrated into Robeson Channel, whereas in Hall Basin there was open water. We have much information concerning ice conditions in these waters from the numerous Polar expeditions during the last fifty years. It would be interesting to try to coördinate ice conditions with the meteorological observations available to determine whether the occurrence of the ice is a local phenomenon or is due to more universal causes.

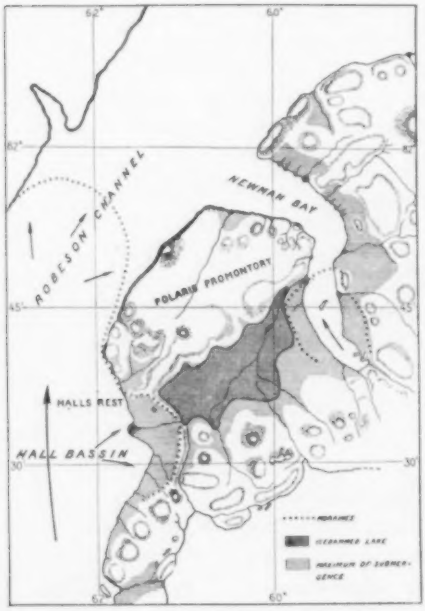

FIG. 2—Hall Land in late glacial times.

THE QUATERNARY EPOCH IN NORTH GREENLAND

Let us now return to the ice cap and consider its past history. What was its former extent? Was the whole of North Greenland covered with ice during the maximum of the Glacial Epoch? The question has been discussed by Chamberlain and Salisbury and several others. My opinion is that no inconsiderable number of precipitous isolated mountains must have risen above the ice cap even at its thickest. Such areas, however, are of limited extent. All the rest of the surface was entirely covered with ice, as may be seen from the numerous erratic blocks that lie scattered everywhere, even

on the plateaus along the northern coast. The mountain range that I observed along the northern coast of Greenland in 1917 changes its character, however, towards Peary Land. While the western part is plateau-like, farther eastward it exhibits alpine summits attaining heights of some 2000 meters. During my journey in 1921 I tried to find out if this mountain range had been covered by the ice during its maximum extension. When on my journey eastwards I reached the northern coast of Peary Land proper, I found that the highly fossiliferous erratic blocks, common farther south, were absent, as were also the gneiss blocks from the interior of Greenland. Not until reaching Schley Fjord on the east coast of Peary Land did I encounter again the fossiliferous erratics. Furthermore, in the regions beyond the eastern point of Peary Land they were also lacking. It was not until I reached Cape København farther southward that I got the solution of the riddle. From Cape København a vast belt of moraines runs west of the plateau that forms the eastern part of Peary Land, thence seaward into Schley Fjord, and thence westward along the southern edge of the mountain range (Fig. 1). In the moraines were several blocks of rocks found farther south, whereas such blocks were entirely absent north and east of the moraines. In other words the belt of moraines indicates the maximum extension of the ice cap during the maximum of the Glacial Epoch. The northern half of Peary Land has never been covered by the ice cap. In the first place this is due to topographical conditions. The southern part of Peary Land is a low plateau, whereas the northern part consists of alps more than 2000 meters high. However, these alps have once been covered by the local glaciers to a greater extent than is now the case; but I believe that there must have been considerable ice-free regions even then. The dry climate that no doubt prevailed in these regions during the Glacial Epoch was very likely a concurrent cause.

The retreat of the ice at the termination of the Glacial Epoch was not continuous. In two places, at all events, moraines have been found that seem to show a halt in the retreat. I refer to morainic masses found in the depression formerly known as Peary Channel, which have had no slight influence on the water streams. This may be observed even more distinctly on Hall Land (Fig. 2). The northern part of Hall Land must soon have become ice-free, and later also the level plain behind; but the two depressions on either side, namely Hall Basin-Robeson Channel and Newman Bay, have constantly been filled with great glaciers. These glaciers in some degree extended over the level part of Hall Land; they must both have had flank moraines, between which a large ice-damned lake must long have existed. Eventually it drained along the eastern moraine into the northern part of Newman Bay. Whether the morainic systems in the "Peary

Channel" depression and the moraine on Hall Land were contemporary cannot be settled as yet; only in these two places have I succeeded in ascertaining any considerable halt in the retreat of the ice.

After the maximum of the Glacial Epoch the land began to subside, and it is quite certain that during this subsidence, at all events, the ice cap was not more extensive than at present. This subsidence has been shown to have been 210 meters; above this limit there are in several places suggestions of shore lines; for the present, however, I dare not estimate it at more than 210 meters. That the ice cap, when the subsidence was at its maximum, was farther withdrawn than now is probable but not certain. On the other hand, it can be said for certain that during the maximum subsidence there was a great pressure of drift ice against the east coast of Peary Land. At a height of 200 meters I found in the soft clay the characteristic crushing that is very common along the present coast line, and which is due to the pressure of the drift ice. Subfossil shells are common in North Greenland, especially in the great fiords. Shells are found up to a height of 135 meters, and in the eastern part of Peary Land driftwood is found up to a height of 165 meters. Unfortunately all the species of animals found are forms which still live in the northernmost part of Greenland. In the interior of Independence Fjord there is a skeleton of a whale, and in the clay masses which the Academy Glacier presses against the flank moraines 10 kilometers from its present terminus are found mussel shells. This would seem to indicate that Independence Fjord was once ice-free to a greater degree and that the glaciers in this fiord did not advance as far as at the present time, but it cannot be taken as proof of an improvement of the climate of long duration.

Afterwards the land again rose. Especially along the northern coast of Greenland two distinct shore lines may be observed, one at a height of 105 meters and the other at about 65 meters. Farther southward, for instance in the Cape York district, the most typical shore line is about 50 to 55 meters high. Whether the movement was differential and the 50-meter line thus corresponds with the 65 meters on the north coast, cannot be definitely asserted but is very probable. As far as can be observed, during the subsidence of the land the glaciers did not extend farther than at the present time. One isolated glacier on the north coast, however, is an exception, as it has advanced a kilometer across areas which were formerly covered by the sea.

The Latest Phase

It seems as if the inland ice since the maximum of the subsidence had varied little in North Greenland, but here as elsewhere there are naturally small oscillations in the various glaciers. Unfortunately we

have hardly any earlier observations, and for this reason I shall here only mention the observations that I have made myself.

In August, 1916, I mapped the Moltke Glacier in the head of Wolstenholme Fjord. In April, 1923, I remeasured it. During the interim of 80 months this glacier had receded more than 2600 meters. A smaller glacier which I measured on Inglefield Land in 1917 and again in 1920 had advanced 400 meters, but a new observation in 1922 showed a retreat of 700 meters. This process, viz. advance until 1920 and afterwards retreat, seems to be typical of many of the glaciers in the Cape York district.

The only glacier I know in North Greenland that seems to have constantly advanced during many years is the famous Brother John Glacier. From Kane's and Hayes's descriptions and maps we know that at that time it did not reach Alida Lake; and even at the time of Nares's expedition a little of the land behind the lake was left, but since that time it has constantly advanced. In 1917 I saw it for the first time. In 1922 I measured it very carefully, and it appeared that during the past five years it had advanced considerably.

Photographs taken by Peary and his companions also bear witness as to the small changes in the ice cap glaciers of northern Greenland. The ice cap here, as in western Greenland, has varied very little from year to year.

THE FIRST STEAM VOYAGE TO INDIA

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IN the sixteenth century began the far-reaching movement known as the Commercial Revolution, which was characterized by a partial desertion of the Mediterranean for trading purposes and the rapid extension of oceanic navigation to all parts of the known world. Late in the eighteenth century there began in England a closely related movement, the Industrial Revolution, which by rapid machine production of manufactures undertook to exploit the vast markets opened up by commercial and colonial expansion. It was quite natural that this new industrial era should open in that country whose interests abroad were already greater than those of any other nation. The Industrial Revolution, rapidly spreading throughout Europe after the Napoleonic Wars, profoundly affected every element of modern life. It called for greater supplies of raw materials, it demanded improved marketing facilities, it magnified the value of colonial possessions, and it produced new problems in international relations. All of these changes placed enormous stresses on the facilities for transportation and communication, which led during the nineteenth century to such vast developments along these lines as to constitute a veritable revolution, as distinct from the industrial movement proper as it was from its commercial progenitor. This revolution in communication was ushered in with the application of steam to transportation, and it is with one of the early steam voyages that we are here concerned.[1]

Need of Improved Access to India

At the beginning of the nineteenth century the English were deeply absorbed in the problem of improved access to India. British interests in that part of Asia had long been of first importance, but they were rapidly acquiring additional value because of the industrial movement. England's cloth exports to India multiplied fifty fold in the fifteen years after the Congress of Vienna. Moreover, the safety of the entire English structure in India had been gravely threatened by the French on two occasions during the Napoleonic era. Hence there came an increase of public interest in the steamship as a practicable means of bringing India within closer touch. As

[1] Cf. H. L. Hoskins: The Growth of British Interest in the Route to India, *Journ. of Indian History*, Vol. 2, 1923, pp. 165–177

late as 1825 it generally required from five to eight months to transmit messages from the Court of Directors of the East India Company in London to the Governor-General at Calcutta, and replies to official inquiries which were transmitted by way of the Cape of Good Hope were frequently not received within a period of two years.

English shipbuilders were constructing steam vessels for domestic use before the end of the Napoleonic wars, contemporaneously with the application of steam power to the great river systems of North America. By 1815 steamboats were in regular operation on the larger canals and rivers and a few years later were making regular trips across the English and Irish Channels.[2] Before 1820 far-sighted individuals were predicting the early application of steam to trans-oceanic transportation,[3] and in 1823 a series of campaigns was launched simultaneously in England and in the Indian presidencies for the establishment of steam communication either through the Mediterranean, in conjunction with the opening up of some logical overland route to the Indian Ocean, or around the Cape of Good Hope.[4]

Revival of Mediterranean Route Suggested

In connection with the rise of steam navigation there were good reasons for the revival of the old routes to India leading from the eastern Mediterranean. This is largely explained by the character of the early steam vessel itself, which was at once a very expensive and highly inefficient mechanism. Among the many difficulties encountered in the early days of oceanic steam navigation were the incrustation of boilers and pipes by salt water, damage to paddle wheels from high seas, the inefficiency of steam pumps, and faulty design and workmanship in general. Frequent stoppages were necessary for the lubrication and readjustment of machinery, and extensive repairs were often called for, demanding access to specially equipped foundries. The low degree of efficiency of early marine engines required the burning of large quantities of coal, even for short voyages. Steam vessels, even when assisted by sails, were poorly adapted a century ago to any long-sustained voyage, such as that around the continent of Africa to the Far East. It was much more likely that they might prove practicable if employed on either side of the land masses separating the Mediterranean from the Indian Ocean, since by such a line the total distance between England and India was not more than a third of that by the all-sea route.

[2] Interesting contemporary accounts of the development of steam navigation in English waters are contained in *British Parliamentary Papers*, 1834, Vol. 14, No. 478.

[3] For example Mr. John Barker, the English Consul-General in Egypt, publicly broached the idea as early as 1815 and attempted to take up the matter of steam communication with India with members of the British Government in 1816 but was reproved with the statement that this was a matter "not in his competence."

[4] *British Parliamentary Papers*, 1831–32, Vol. 10, Part II, pp. 765–766.

Other factors also suggested the use of the Mediterranean and adjacent waterways for a communication by steam vessels at a time when the traditions of eastern navigation were wholly attached to the Cape route. Precedent already pointed to the use of the shorter routes. Late in the eighteenth century a considerable saving of time had been effected, even with the use of sailing vessels, by sending despatches either way between England and India through the Mediterranean and over a combination of land and water transit beyond. One of these combination routes, extending through Egypt to the head of the Red Sea, was frequently employed between 1773 and 1798. After 1798, however, because of the extent of French influence in Egypt, it was seldom used for any kind of communication until after 1830.[5] Meanwhile the British and Indian Governments did employ at frequent intervals an "alternative route" through Syria and Arabia to the head of the Persian Gulf, and thence the contacts with the port of Bombay were maintained by armed cruisers or native boats (baggalas). During the Napoleonic Wars despatches by this route were sometimes transmitted entirely overland from German North Sea ports to Vienna and thence via Bucharest to Constantinople, Aleppo, Baghdad, and Basra, a line closely approximating that which made the Baghdad Railway famous—and dangerous—a century later.

After some years of inaction there was about 1820 a sudden burst of interest in the revival of a shorter passage to India. In addition to the influences already mentioned, the growing power of Russia in the East was becoming a matter of concern. Interest was stimulated also by the publication of the experiences of travelers to or from India, who agreed that, for passengers as well as mails, the route via Egypt and the Red Sea could be used with a considerable gain in time if not in comfort.[6] However, it was the growing efficacy of the steam vessel which carried speculation to the test of experiment.

The First Definite Scheme

The first definite scheme recorded for a regular line of steam vessels between England and India, utilizing the "overland" route

[5] H. L. Hoskins: The Overland Route to India in the Eighteenth Century, *History: The Quart. Journ. of the Historical Association*, Vol. 9 (N. S.), 1924–25, pp. 302–318. In 1802 and for some time thereafter mails were being sent to England from India both via Suez and Cairo and via Basra and the Syrian Desert. At this time private messages were occasionally despatched by one or the other of these routes as well (*India Office, Factory Records, Egypt and Red Sea*, Vol. 6, *Loose Papers*, Bundle 1, Packet xi, Nos. 2, 10, *et passim;* E. B. B. Barker, edit.: Egypt and Syria Under the Last Five Sultans of Turkey, Vol. 1, pp. 55 and 96).

[6] Mrs. Colonel Elwood: Narrative of a Journey Overland from England . . . to India, . . . in the Years 1825, 1826, 1827 and 1828, 2 vols., London, 1830; Lieutenant-Colonel Fitz-Clarence: Journal of a Route across India, through Egypt to England, in 1817–18, London, 1819; Mrs. Charles Lushington: Narrative of a Journey from Calcutta to Europe, by way of Egypt, in the Years 1827 and 1828, London, 1829; *British Parliamentary Papers*, 1831–32, Vol. 10, Part II, pp. 726, 735; *Asiatic Journ.*, Vol. 3 (N. S.), 1830, Part I, pp. 196–206.

through Egypt, was the work of an English naval officer, James Henry Johnston. In 1822 he attempted to form a company with the object of establishing a steam line between Calcutta and Suez. He was able to secure some financial support in London, where capital was becoming available for almost any kind of new enterprise. To complete the financing of his concern he sailed for Calcutta. Here, however, the proposition did not appear sufficiently practicable to any of the great interests involved. The objections to the plan were obvious and many. The cost and operation of steam vessels was very considerable. No attempts had been made to determine whether a steam vessel could profitably operate on a line as long as that from Calcutta to Suez, even with intermediate stops. It was also exceedingly doubtful whether a steamer could operate on this line at all during those months in which the southwest monsoon held sway over the Indian Ocean. Moreover, there was no knowing whether political conditions in Egypt and in Syria would permit of uninterrupted communication between Suez and Alexandria. In any event, the proposed company would not soon be able to develop the Mediterranean end of the line, which would be essential to any regular service. In the absence of any government support, Johnston's project would indeed have been a reckless venture for the investor. But his proposition was not without result. Early in 1823 a number of interested citizens of Calcutta, styling themselves a "Steam Committee," called a public meeting for the purpose of considering the plan of steam communication. The immediate financial response was disappointing; but the meeting proceeded to organize permanently as a "Society for the Encouragement of Steam Navigation between Great Britain and India" and, by generous subscriptions to a "Steam Fund," laid the foundations for the eventual realization of their hopes.[7]

Meanwhile the Supreme Government of India, which under the Marquess of Wellesley had taken the initiative in promoting rapid despatch service during the Napoleonic Wars, was prepared to revive and expand that service. In May, 1823, the new Governor-General, Lord Amherst, wrote the Court of Directors of the East India Company as follows:

> We have for some time past been engaged in inquiries respecting the practicability of opening a communication with England through Egypt by means of steam vessels, and observing from the public prints that the subject has also been agitated in England, we consider it will be acceptable to your Honourable Court . . . to be assured, in case your Honourable Court should be disposed to sanction the arrangement, that the difficulties on this side of the Egyptian Isthmus are not greater than on the other. . . .
>
> The great advantage of the steamboat is, that it is independent of the wind. It would therefore go through all the seas between this and England, and at all seasons, nearly at the same rate. . . .

[7] *Calcutta Government Gazette*, January 17, 1827; *British Parliamentary Papers*, 1831–32, Vol. 10, Part II, pp. 675–766.

> Egypt has seldom or never been so disturbed as to stop our packets, but if it were so, the steamboats might for the time go to some port in Syria on the one side, and to Bussora on the other, so that the packet would still pass with great rapidity, though not so quick as through Egypt. . . . [8]

On the basis of these considerations, Lord Amherst suggested that the East India Company place two steamships in operation on each side of the Isthmus of Suez, two vessels being considered sufficient for the beginning of a monthly steam service. His optimistic view was not shared by the materialistic Court of Directors, who completely ignored the proposal. It was more than a decade before the Court sanctioned the expenditure of any funds for the development of steam lines of their own, and then only under duress.

Government Aid Secured

At this juncture, however, with both the Government and the public of Bengal interested, a degree of coöperation was effected which brought the object a step nearer realization. The "Society for the Encouragement of Steam Navigation between Great Britain and India," upon completing its organization, at once submitted plans to the Supreme Government, soliciting patronage and financial contributions to the cause from the public funds of the Presidency. At first doubtful of the wisdom of applying public moneys in support of a private organization whose purposes were still somewhat vague, the Bengal Government later (December 31, 1823) reported that, in view of additional information and mature reflection, "We accordingly resolved to place at the disposal of the Committee the sum of 20,000 rupees as a contribution toward the attainment of the object in question."[9] But this financial grant was rigidly conditioned by requiring that any steam vessels despatched from England to India with the view of obtaining as a reward a portion of the Steam Fund should be of not less than 300 tons burden,[10] that not more than 100,000 rupees (one lac) should be granted by the Steam Committee to any single contestant, and that two round trips must be made between England and India before any bonus could be claimed.

The terms of the Government grant of 20,000 rupees practically determined the conditions under which the Bengal Steam Committee undertook to bring about the commencement of steam communication. At a meeting held on December 17, 1823, the Committee resolved,

> That the amount received under the subscriptions opened for this purpose, . . . or if the net receipts from the subscription shall exceed . . . one lac of

[8] *British Parliamentary Papers*, 1831–32, Vol. 10, Part II, p. 726.

[9] *Asiatic Journ.*, Vol. 18 (O. S.), 1824, p. 488.

[10] This provision was inserted in ignorance or defiance of a law on the English statute books that no vessel of less than 500 tons burden might be permitted to sail between England and India. Possibly the law was interpreted as applying only to sailing vessels. The first steam vessel to attempt to reach India from England was, however, of 500 tons.

Sicca Rupees, so much therefore as shall amount to that sum, be assigned, as a Premium, to any individuals, or company, being British subjects, who may first establish a Communication by Steam Vessels between Great Britain and Bengal, by either of the routes above-mentioned, before the expiration of the year 1826.[11]

Other details of the offer repeated the conditions of the Government donation and added that the minimum of four steam voyages between England and Bengal must average not more than seventy days each.[12]

The Cape Route Selected

The nature of the Committee's award and the date by which the four voyages had to be completed appeared to argue in favor of the Cape route. Here only one vessel was required for the purpose in hand, and, because of the nature of the prevailing winds along the route, sails might be successfully employed as auxiliary power. The prospect of large reward attracted a considerable number of promoters both in India and in England, and none more powerfully than Captain Johnston. He readily altered his earlier plan of establishing a line of steam vessels between Calcutta and Suez in favor of one by way of the Cape of Good Hope and hastened back to England to complete his arrangements. Once in England he had little difficulty in effecting the organization of a steam navigation company with a proposed capital of £200,000.

During the year and a half following the publication of the Bengal Steam Committee's prize offer, Captain Johnston and his associates were feverishly at work on the construction of their large steam vessel in the hope of forestalling any possible rival. This was to be a pioneering venture in more than one respect. The vessel was to be a monster of 500 tons burden in view of the distance to be traversed, the heavy seas to be encountered, and the large amount of fuel to be carried. The ship was no larger than many of the Indiamen in the East India Company's fleet, it is true, but this was the first steam vessel built in England designed exclusively for service on the high seas.[13]

While the vessel was building, the wildest rumors were afloat. So unfounded were the claims made that the subsequent failure to measure up to these sanguine expectations caused a very decided reaction against any plan for the application of steam to the longer ocean routes for years to come.

Report was also current that other great steamships were being secretly prepared for the voyage to India in the hope of capturing the prize money. But, whatever plans may have been on foot, Captain

[11] *Quart. Oriental Mag.*, Vol. 7, p. xix.

[12] Neither of the other Indian Presidencies assisted in this, as there was little feeling of unity and much of jealousy among the Anglo-Indian communities at this time, even in matters of general concern.

[13] C. R. Low: History of the Indian Navy (1613–1863), 2 vols., London, 1877; reference in Vol. 1, pp. 520–521.

Johnston was the first to complete preparations for a steam voyage. In March, 1825, the *Oriental Herald* regaled its readers with the intriguing statement that

> We are at length enabled to announce the certainty of a Steam-Vessel sailing for India by way of the Cape of Good Hope. All thoughts of pursuing the route by the Mediterranean and Red Sea appear to have been judiciously abandoned. In the way now chosen there are no obstacles, but a supply of fuel at intermediate stations, and the weathering of the heavy gales off the Cape. The former is a mere question of expenses. . . . The latter is only to be determined by experiments; but . . . [there is] the strongest ground of hope.[14]

The prospectus of the venture, which was issued by the Company in stating their plans for a regular bimonthly steamship service, said of this their first vessel that "calculations hold out every prospect of her reaching Calcutta within two months from the time of her leaving Portsmouth."[15] This estimate was but one-third or one-fourth of the time usually required for the voyage by ships of the East India Company, but it was supposed that, since a steam vessel would not be dependent on winds, a straight track would materially reduce the distance to be covered.

The Pioneer Voyage

By the time Captain Johnston's vessel was ready, the entire British world awaited with vast interest and deep concern the outcome of the venture. Cynics prepared to scoff and enthusiasts to rejoice. The promoters of the enterprise had such great faith in their calculations and in the performance of the vessel that not even a trial trip was made before the commencement of the voyage. Moreover, the time allowed by the Calcutta Steam Committee was growing short, and final preparations had to be unduly hastened. Those who were fortunate or courageous, as the case may have been, in being taken as passengers for the historic voyage embarked at London about August 12, 1825, and the steamer immediately set out for Falmouth, from which port the official start was to be made. This first stage of the voyage was somewhat marred by a dangerous fire, resulting from the stowing of coal directly over the engine boilers. The incident was minimized and hushed up as much as possible by the Company's officials, and little time was lost. On August 16 the pathfinding steamer, happily named the *Enterprize*, steamed out of Falmouth harbor for Calcutta with flags flying and great paddle wheels churning, bearing important despatches and seventeen passengers.[16]

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[14] *Oriental Herald*, Vol. 4, 1825, p. 395.

[15] *Ibid.*, p. 396.

[16] *Ibid.*, Vol. 6, 1825, pp. 580–581; *British Parliamentary Papers*, 1834, Vol. 14, No. 478, p. 208.

News of the voyage drifted back to England from various points along the route. Almost from the outset it became apparent that the anticipated progress was not being made. Subsequently it appeared that the enormous weight of the coal with which the ship started and its improper location on board gave the vessel an unlooked-for draft and seriously impeded progress for a considerable time. Storms and head winds caused further delay, providing great handicaps for a paddle steamer where a balanced immersion of the wheels was necessary to effective operation. Finally, after the original fuel supply had been exhausted in the South Atlantic, the *Enterprize* was compelled to change tack and depend entirely on sails in order to reach the Cape still several hundred miles away. After leaving Cape Town, where the only coal depot had been located, the voyage was largely a replica of the first portion—bad weather, exhausted fuel, and use of sails. Calcutta was reached only after the expiration of 113 days, of which 10 had been spent at anchor, 40 entirely under sail, and only 62 under steam.[17]

Results of the Voyage

Although bitterly disappointing to those interested in ocean steam navigation, the voyage of the *Enterprize* was in many respects remarkable. Considering the experimental stage of steam navigation and the nature of the difficulties to be overcome, the fact that the voyage was completed in less time than was often required for sailing vessels, indeed, the fact that it was completed at all, warrants its being rated as something of a triumph. Yet because the conditions laid down by the Calcutta Steam Committee were not met as to the time consumed in transit, and because of the considerable dependence on wind propulsion, the trip in contemporary eyes was generally considered a dismal failure. Even Captain Johnston himself admitted before a Select Parliamentary Committee a few years later that he was thoroughly convinced that the communication between England and Calcutta under the existing state of steam navigation could never be accomplished but at a heavy sacrifice.[18] A few other experimental steam voyages made around the Cape of Good Hope about the same time only strengthened this conclusion.[19]

[17] *Asiatic Journ.*, Vol. 20 (O. S.), 1825, pp. 371, 487–488; Vol. 21 (O. S.), 1826, pp. 633–634 and 785–786; *Oriental Herald*, Vol. 6, 1825, pp. 580–581; Vol. 9, 1826, pp. 360–361.

[18] *British Parliamentary Papers*, 1831–32, Vol. 10, Part II, pp. 494–495.

[19] *Quart. Oriental Mag.*, Vol. 7, pp. xix-xxi; *Oriental Herald*, Vol. 9, 1826, pp. 360–361; *Asiatic Journ.*, Vol. 22 (O. S.), 1826, p. 607; *British Parliamentary Papers*, 1834, Vol. 14, No. 478, pp. 1–5. The *Betsey*, of Bordeaux, was one steam vessel which made the voyage to India in the same year but with no greater success than that of the *Enterprize*, sails having been largely relied upon. A year or so later a Dutch steamship, the *Atlas*, 230 feet long, 1800 tons burden, with engines totaling 300 horse power, undertook to establish a steam communication with the Dutch East Indies. This large vessel is said to have been more completely a failure than was the *Enterprize* (Observations on the Advantages and Possibility of Successfully Employing Steam Power in Navigating Ships between this Country and the East Indies, London, 1829, pp. 6–7).

The acknowledged failure of the *Enterprize* was a great blow to the promoters of the project and to the plans of the Anglo-Indian community at Calcutta. The owners of the vessel were threatened with a considerable loss, since the reward of the Bengal Steam Society could not be claimed, and the vessel was obviously incapable of making regular voyages around the Cape. Partial relief for the investors was furnished, however, by the purchase of the steamer by the Bengal Government for £40,000, which was approximately the cost of building.[20] For several years thereafter the *Enterprize* gave a good account of herself in eastern waters. During the Burmese War she was employed in carrying despatches and towing transports to and from Rangoon.[21] Thereafter she was used in coastal voyages and in towing on the Hooghly River before she was dismantled in 1838.

The pioneering efforts of Captain Johnston were also not permitted to go altogether unrequited. In 1827 the Calcutta Steam Committee voted him one-half of the existing Steam Fund, the other half being reserved for other meritorious attempts of a similar kind. Captain Johnston continued for a time in command of the *Enterprize* and spent the remainder of a very useful life at Calcutta originating and developing lines of steam vessels on the great river systems of India.[22]

Subsequently to the first voyage of the *Enterprize* sentiment in England and in many parts of India veered toward the Mediterranean and the Red Sea. A small steamer, the *Hugh Lindsay*, using Bombay as a starting point, demonstrated the feasibility of the eastern end of such a line by making a successful voyage to Suez and return in 1829. Yet several years more were wasted in futile discussions and idle projects before a practical steam communication was established between England and India by way of Egypt. Meanwhile, confidence in the Cape route from the point of view of rapid communication with India steadily declined, not to be again revived. New traditions presently grew up about new British routes to India which followed the more direct lines impinging on the eastern Mediterranean.

[20] *British Parliamentary Papers*, 1831–32, Vol. 10, Part II, pp. 494–495.

[21] *Asiatic Journ.*, Vol. 21 (O. S.), 1826, pp. 634 and 785; Vol. 22 (O. S.), 1826, pp. 600 and 713–714; Low, *op. cit.*, Vol. 1, p. 521.

[22] *Calcutta Government Gazette*, January 17, 1827; *Asiatic Journ.*, Vol. 8 (N. S.), 1832, Part II, p. 225; Vol. 9 (N. S.), 1832, Part II, p. 101.

THE DISTRIBUTION OF THE DATE PALM

Paul Popenoe

WRITERS on the resources of the Moslem world commonly give little definite information about one of the most picturesque as well as valuable of its resources—the date palm. With sufficient effort, however, it is possible to bring together many more data on the subject than one might at first suppose. In the more highly organized countries of its occurrence, where the palm is subject to taxation, it is enumerated in the periodical census. Elsewhere, the estimates of travelers must be depended on. A summary of all the available sources of information indicates that there are in the entire world something like 90,000,000 date palms, of which more than half are in the countries bordering on the Persian Gulf. Iraq is far in the lead.

Iraq and Persia

According to Mr. Dowson[1] there are about 30,000,000 palms in Iraq, of which one-half are on the Shatt-al-Arab, 5,000,000 on the banks of the Hillah canal, a million around Baghdad, and the remainder on the Euphrates and in separate oases.

The most important plantations in Persia are those on or near the Persian Gulf, but there is also a large production in some of the highland regions as far north as Tabas. On the Persian side of the Shatt-al-Arab, opposite the Basra region, V. H. W. Dowson calculates the number of date palms to be something like 3,750,000. From Dr. Fairchild's report, there must be not less than 5,000,000 in the Minab region near Bandar Abbas; and there are said to be at least 250,000 in Tangistan. I have been unable to find even guesses as to the number of palms in other parts of Persia, but if the grand total is put at 10,000,000 it will perhaps serve the present purpose.

India and Baluchistan

E. O'Brien[2], formerly deputy commissioner of Multan, says that the date palm grows in literally hundreds of thousands in the Multan, Muzaffargarh, Dera Ghazi Khan, Dera Ismail Khan districts, and perhaps in Bannu; also in Jhang, Bahawalpur, and Sind. Milne[3] cites the following figures for the number of female palms in three of these

[1] V. H. W. Dowson: Dates and Date Cultivation in the Iraq, 3 vols., Cambridge, 1921–23.
[2] Quoted by E. Bonavia: The Date Palm in India, Calcutta, 1885.
[3] D. Milne: Date Cultivation in the Panjab, Lahore, 1911.

districts: Multan, 315,055; Muzaffargarh, 838,999; Dera Ghazi Khan, 126,384; total, 1,280,438.

If the figures given by Mr. Milne be arbitrarily doubled to cover all the rest of northwestern India, one would arrive at a total of about 2,500,000 female palms. Mr. Milne states that in the districts he has visited about 50 per cent of all palms are males, so to get the total number of palms of both sexes, one would have to increase the above estimate to about 5,000,000.

The principal centers of cultivation of the palm in Baluchistan are the Panch Ghur valley, where there are said to be about half a million palms, and Kach in Makran.[4] Presumably the total number in the country cannot be less than one or two million.

Arabia and Syria and Palestine

Hasa proper was credited with 2,000,000 palms in the Turkish census of 1877, while Dr. Fairchild estimates the number at Qatif as 1,250,000, making the total for this district 3,250,000.

In the Bahrain Islands Dr. Fairchild estimated the number of palms at 500,000, a figure that may be too high.

Oman is credited with 4,000,000 palms,[5] the larger part of which are found in the coastal belt known as the Batinah, stretching some 150 miles north of Muscat. Samail valley has half a million palms, and the next most important plantings are at Ibri.

Hadhramaut grows some palms, both on the seashore and on the desert side, but I have found no reports as to their number. At a guess there can hardly be less than 200,000.

Aden grows a few palms along the coast but none in the interior. It is an important point of transshipment for dates from Persian Gulf ports en route to Red Sea ports.

It may be conveniently remarked here that a few dates are grown on the African coast, in Somaliland, Eritrea, and neighboring countries. The production is commercially unimportant, however.

Yemen is mostly too high for the palm, but there are flourishing cultures in the little-known valleys of the interior, such as Jauf and Najran. In the absence of all information, I will put down 100,000 as representing a minimum for these regions.

Asir boasts a few palm groves here and there, but production is probably not sufficient for local needs, save at Bisha. Date production in Asir may be considered negligible, in a world-wide survey.

Hejaz, the sacred territory, is, according to Arab tradition, the true home of date growing, and the culture receives much attention here. The important centers are Al-Ala, Medina, Taima, and Khaibar.

[4] D. G. Fairchild: Persian Gulf Dates, *Bur. of Plant Industry Bull. 54*, Washington, 1903.
[5] *Daily Consular and Trade Repts.*, June 30, 1914, p. 1984.

There are no palms at Mecca. Medina possesses 300,000 palms, according to a report sent me by Gellatly, Hankey, & Co., an exporting firm at Jidda. I doubt if all Hejaz possesses more than 500,000.

Jabal Shammar has not been surveyed by agriculturists, but some information on this, as well as other parts of Arabia, is available in the British Admiralty "Handbook of Arabia" (1920). In the mountains there is only one settled area of any size, namely Aqda, reputed to possess 75,000 palms. Jauf may have 50,000; the Sakaka groves are said to be somewhat more extensive. Making allowance for Hail and smaller oases, the total cannot be much above 250,000.

Qasim deserves special consideration because, according to the opinion of many Arabs, the cultivation of the palm has reached a higher point there than anywhere else. The plantations of Buraida, Anaiza, and Qusaiba altogether contain perhaps no more than 100,000 palms.

Nejd imports most of its dates from Hasa. In central Nejd (the Aridh) the chief centers of date growing are Riyadh and Daraiya. Such photographs as I have seen do not indicate that there are many thousand palms there. Farther south, however, in Wadi Dawasir there is a great horticultural district lately visited by H. St. J. B. Philby, who gives taxation details indicating that the total annual production of dates there is some 5,000,000 pounds.[6] This might represent anywhere from 50,000 to 100,000 palms. Arabic legends of the extensive date groves of Wadi Jabrin, "a palm tract comparable in size, though not in density or fertility, to the Hasa itself" have been set right by R. E. Cheesman (1925).[7] His report in the *Geographical Journal* gives no details of the number of palms, but his photographs and references indicate that there cannot be many thousand. Altogether, I doubt if Nejd should be credited with more than 250,000 palms.

On the whole, then, the interior of Arabia plays little part in the world commerce of dates—a fact well known to geographers but not in accord with popular tradition. It is not even self-supporting. The figures given above are largely guesswork, but at least they are closer guesses than anything hitherto published. Arabia altogether can scarcely possess much more than 9,000,000 palms, of which three-fourths are on the shore of the Persian Gulf, in Oman and Hasa.

There are still a few palms in the hot valley of the lower Jordan, where in classical times the tree flourished; and there is a small production at Gaza. North of this palms are found at isolated points, particularly in the plain of Philistia and near Beirut and Tripoli, but at no point in sufficient numbers to have commercial importance.

[6] H. St. J. B. Philby: The Heart of Arabia, 2 vols., London, 1922; reference in Vol. 2, p. 206.
[7] R. E. Cheesman: The Deserts of Jafura and Jabrin, *Geogr. Journ.*, Vol. 65, 1925, pp. 112–141.

Egypt, Libya, and Cyrenaica

Egypt, according to the census of 1907, had slightly more than 10,000,000 palms to which must be added 46,426 in Arish (the peninsula of Sinai), 3947 in Suez, and some half million in the western oases. The total for Egypt at present is therefore approximately 11,000,000.

For the Anglo-Egyptian Sudan, the Central Economic Board has furnished (1924) detailed figures showing a total of 1,261,629 palms, nearly all in the provinces of Dongola, Halfa, and Berber.

According to the calculations of E. de Cillis[8] the Italian colony must have nearly 9,000,000 palms, or as many as Tunisia and Algeria put together. Most of these, however, are in the interior oases of the Sahara, little subject to Italian control, and the figures may be high. The only exact enumeration is for Tripoli and three neighboring oases (Tagiura, Gurgi, and Gargarese) in which the Italian census of 1917–1918 discovered 285,000 palms. In Tripolitania the Italians calculate that there are 7,800,000 palms, of which about 3,500,000 are in the region comprised in the former Turkish vilayet of Tripoli, which includes Ghadames, Ghat, and the Fezzan. At Ghadames there are said to be 25,000, while the neighboring oasis of Derj is credited with 800,000, Ghat with only 5,000. I have seen no detailed figures for the Fezzan, but the Italians evidently calculate them at more than a million.

In Cyrenaica there are supposed to be about 1,200,000 palms, of which only 20,000 are on the coast, the beautiful oasis of Derna having no more than 8000. Figures for the interior are given by the British Admiralty "Handbook of Libya" (1920) as follows: Aujila, 40,000; Jalo, 100,000; Wadi, 40,000; Leskerre, 20,000; Sella, 100,000. It is evident, then, that more than 750,000 are attributed to the Kufara group of oases—a moderate estimate if the areas assigned to these oases are to be relied on. G. Rohlfs' estimates of palms have almost everywhere been found to be too high, but his estimate of nearly 2000 square miles of land characterized by palms may not be so wide of the mark. Rosita Forbes and Hassanein Bey have given no particulars on this point, but their photographs show that in many districts the palms are widely scattered.

French Africa

Tunisia possesses 2,138,075 palms according to the statistical report of the Regency (1920). The groups of Saharan oases known as the Jerid and the Nefzawa account between them for more than half of these. Other important regions center on Gabes (400,000), Gafsa (50,000), and the island of Jerba (400,000).

[8] Emanuele de Cillis: Saggio de "Fenicigrafia libica": Studi sopra alcune razze di palma da datteri coltivate in Tripolitania, *Minist. delle Colonie Boll. di Informazioni*, Rome, Vol. 11, 1923, pp. 733–819.

Algeria has 7,211,000 palms according to figures furnished by the office of the governor-general (1924). Of these 6,620,459 are in the Territoire du Sud. There are well on to 2,500,000 in the Wad Righ and an equal number in the Tuat oases. In the region Figuig-Colomb-Bechar there are about one million.

Morocco has slightly over one million palms according to figures furnished by the Directorate of Agriculture at Rabat (1924). The Tafilelt oases are credited with a trifle more than half of the total.

While the colonies united under the name of Afrique Occidentale Française are at the southern limit of commercial cultivation of the palm, they stretch so far across Africa that they contain, altogether, enough palms to deserve mention. The office of the governor-general has furnished me with such data as are available. Beginning in the west, there are small and scattered plantations in and just north of Senegal, but the only ones of any size are in Mauritania, where the district of Adrar contains 110,000 and Tagant 73,299. Traveling eastward, one encounters a few palms in almost every oasis and also scattered plantings along the Niger; but the next area of any importance devoted to the industry is not reached until one arrives at Tibesti, at the extreme limit of French territory. Here the plantations are numerous, that of Bardai being the most important. Borku and Unianga also grow quantities of good dates. I have seen no estimate of the total number of palms in French West Africa, but if it be credited with 500,000, the estimate will be conservative.

There are small plantings in French Equatorial Africa, as for example in Kanem and Wadai, but I believe they are not of sufficient size to merit consideration here.

Many seedlings are grown as ornamentals on the northern shores of the Mediterranean, and at Elche, Spain, there are 115,000 grown for their fruit. In Australia, in South Africa (Damaraland and Namaqualand), and in South America (Brazil, Argentina, Peru) there are scattered seedlings, and the prospects of establishing the industry commercially are good. In Mexico (Baja California and Sonora) there are at least 100,000 palms, and in Southern California and Arizona perhaps 150,000.

Conjectural as are many of the data presented in this review, they are fortunately most trustworthy for the regions with the largest date industries, so that the correctness of the total is less affected. If the total number of palms in the world be calculated at 90,000,000, I believe future investigation will prove this figure to be within 5 per cent of accuracy.

THE ANALYSIS OF LAND FORMS

WALTHER PENCK ON THE TOPOGRAPHIC CYCLE

Isaiah Bowman

BETWEEN the crust of the earth and the forces of erosion there is an unequal interplay that has brought into being land forms of extremest variety. In the primitive view of earlier generations these were looked upon as the products of great convulsions of nature, but De Saussure in the first instance, and Hutton soon thereafter, began to explain them on the principle of uniformitarianism—that is that they are the product of the agencies that we see at work about us today. The discovery and application of this simple fact, first in the Swiss Alps and then in Scotland, marked what might be called the dawn of modern physiographic research. Even before this the old dread of mountains had generally disappeared, and in its place there arose an appreciation of scenery; but even with the advance of scientific interest the descriptions of the forms of the land were almost universally couched in picturesque or romantic terms. Physiography as the naturalistic basis of human affairs was not taken into consideration. "The still small voice of the level twilight on purple hills"—such was the romantic fashion in describing scenery in the vague phraseology of color and form.

American Studies and the Topographic Cycle

The analysis of land forms had no broadly scientific basis until "the refreshing juice of explanation" began to flow. It reached its climax in America in a period marked by four great names: Powell, Gilbert, Dutton, and Davis. While the principle of evolution had been applied to the crust of the earth through the work of De Saussure and Hutton half a century before the theory of biological evolution was launched by Darwin, yet it was a feebly developing idea at best until a period of robust manhood was expressed in the writings of these four men. Inspired by the scope and meaning of the great events so clearly recorded in the enormous sedimentary deposits of the Southwest and especially in the Grand Canyon region, there was begun a group of studies that may fairly be said to have become the foundation of modern geology and physiography. In this development Powell's work was noteworthy for the forceful ideas it conveyed of base-leveled land surfaces; Gilbert and Dutton excelled in their analyses of individual features; Davis systematized the sequence of forms through

an ideal cycle and provided a terminology. As early as 1885 Davis had gone far beyond the theoretical stages and made specific applications of his ideas in Montana[1] and later in much greater detail in the East.[2]

Before Davis had developed and extended the idea of the topographic cycle there had been no approach to full technical equipment for the exact description of landscapes. It was botany with the systematic terminology of the parts of plants left out. The widest acceptance was immediately given to three terms—youth, maturity, and old age—which he adapted from an earlier and somewhat different use of the terms young and old already employed by Chamberlin. Quick acceptance followed, partly because these terms seemed to be adapted to the most divergent forms made upon many types of rock almost everywhere in the world, partly because they fitted the evolutionary mode of thought that had pervaded the whole of science. It would surprise the non-physiographic reader to know how widely the fundamental ideas of physiography have spread. The accepted technique of description came to include a three-part analysis which expresses the evolutionary idea in the following terms: (1) What was this mountain (for example) before it was uplifted? (2) What agencies of erosion have acted upon it since and with what intensity and observable results? (3) What stage has it reached in terms of the whole sequence of stages from its initial to its ultimate form?

Criticism of the Topographic Cycle

During the past fifteen years increasing criticism of the idea of the topographic cycle has appeared in foreign literature. New methods of attack have been proposed in the avowed belief that the alleged simplicity of the topographic cycle was illusory. Too many facts were thought to be in disharmonious relation to the simple scheme of uplift and subsequent erosion through youth, maturity, and old age. The objections seem to spring in large part from an unwillingness to accept a terminology of foreign origin and in part from an inexplicably persistent misunderstanding of *stage* to mean *age*, a failure to see that the word stage is employed as a measure of development not of time. Of a piece with this is the refusal to describe two parts of a single valley as mature where excavated in weak rock and young where excavated in more resistant rock, again overlooking the distinction between *time* and *stage*.

One of the most extreme reactions against the idea of the topographical cycle is illustrated by Passarge.[3] He has sought to describe

[1] W. M. Davis: Relation of the Coal of Montana to the Older Rocks, Tenth Census of the United States, 1880, Vol. 15, 1886, pp. 697–757.

[2] *Idem:* The Rivers and Valleys of Pennsylvania, *Natl. Geogr. Mag.*, Vol. 1, 1889, pp. 183–253.

[3] *Idem:* Passarge's Principles of Landscape Description, *Geogr. Rev.*, Vol. 8, 1919, pp. 266–273.

landscapes in non-explanatory terms, just as Sven Hedin in his journeys in Central Asia claimed to make only *observations*, leaving to "armchair theorists" the explanations of things. The most charitable opinion on such declarations is that the authors are unacquainted with the technique of logic, for in reality explanation everywhere creeps into their work, sometimes directly through inadvertence and sometimes by implication that can hardly be avoided. Even in drawing a simple cross section, inferences have to be made as to underground structures beyond the range of direct observation. To describe a landscape in empirical terms is to offer the reader an ideal of complete meaninglessness and deadly monotony. It is tilting at a man of straw to say that one chooses the empirical method in contrast to theoretical explanations not based upon direct observation. The attempt to study regional geography through a card catalogue of facts-to-be-observed is to guarantee complete sterility. Preoccupation with the filling in of the blank spaces of the outline shuts out discovery. Ideas run the world, not outlines or catalogues. Chamberlin thinks that one sees better if one goes out with an idea in his head to start with: the history of science corroborates the thought. After all, as Gilbert so wisely stated, it is the philosophy of science rather than its material that is of the greatest value to the human spirit.

Walther Penck's Study

One of the most important advances in physiographic study made during the past ten years is a book entitled "Die Morphologische Analyse" by Walther Penck, who died in 1923. The book was edited and published posthumously by his father, Professor Albrecht Penck of Berlin, in 1924. Excellently printed and bound, with illustrations of extraordinary fineness, it is to be commended for thorough reading to every American student of physiography. Fortunately, Penck has followed the explanatory method; it is the outstanding quality of his book. His ingenuity and genius in the analysis of land forms were first exhibited in a most important study entitled "Der Südrand der Puna de Atacama," published in 1920 and based upon field work carried out in 1912.[4] No such detailed and penetrating analysis of the physiography of a district has been made for any other part of South America.

As a result of his studies in northwestern Argentina and later in Anatolia and Central Europe, Penck essayed to rewrite systematic physiography and to place it upon a new foundation. It was not an expansion or adaptation of the subject as now developed but an entire revolution that he sought to bring about. Since his work is the clearest

[4] Reviewed by Alan G. Ogilvie: Argentine Physiographical Studies: A Review, *Geogr. Rev.*, Vol. 13, 1923, pp. 112–121. See also references in Isaiah Bowman: Desert Trails of Atacama, *Amer. Geogr. Soc. Special Publ. No. 5*, 1924.

and most profound of those who have criticized what might be called the American school of physiography, it deserves extended notice, for it is a book that cannot be lightly put aside. Eventually, and as it becomes better known, its arguments will have to be met paragraph by paragraph. For the present we can only indicate the more general features of the argument and point to the difficulties in which the author becomes involved in making his most conspicuous applications.

Penck believes what I think is not true, namely, that according to the current explanation of the cycle of erosion, progress in the cycle takes place *always in a definite sequence;* so that mature land forms follow on youthful, and old forms develop out of mature. This is an altogether elementary and rigid conception, and its only conceivable excuse is its exotic origin. Instead of the sequence—youth, maturity, old age—being an inexorable thing, the orderly progress of the cycle is conceived by Davis to be subject to interruption at any time, whereupon a new cycle or partial cycle (epicycle) may be begun, only to be interrupted in turn, and so on.[5] While Penck fully recognizes the value of the idea of the topographic cycle as a method of investigation, he puts it aside as something not to be accepted as a definite theory of broad application. He regards it as *a special case* in the general physiography of the lands. Well, the uninterrupted cycle, continued to its completion, is undoubtedly a special case; but there is nothing new in that.

While Penck believes that the introduction by Davis of the time factor in the evolution of topographic relief was a very great step forward, he considers it an equally progressive step to bring into consideration the relative rapidity of the three processes of uplift, erosion, and denudation. He thinks that "the Davis cycle" does not take into consideration the constant movement of the earth's crust from the beginning. In his view the *mobility of the crust of the earth* should be an integral part of the cycle theory. Once this principle is accepted, the partial cycle of Davis, that is the epicycle, would not be needed to explain the forms in a given case. It is of the utmost importance that anyone who wishes to understand Penck should fasten his attention upon this *factor of crustal mobility*, or, as he would put it, the *principle* of mobility, for it is upon that principle and its corollaries that he would found the whole of geomorphology or physiography. While granting the pedagogical value of the simpler statement of the theory that Davis is supposed to have given, Penck believes in a new and entirely different formulation of the cycle theory. What his formulation really amounts to is only a more explicit and detailed consideration of the *complications* of the cycle that Davis treats more briefly.

[5] W. M. Davis: Complications of the Geographical Cycle, *Rept. Eighth Internatl. Geographical Congress*, 1904, Washington, D. C., 1905, pp. 150–163.

In order to obtain a clearer notion of Walther Penck's views, I exchanged letters with his father, Professor Albrecht Penck, for the purpose of making the matter clearer. With his permission I quote a statement which holds that it is not a modification of Davis' theory of the topographic cycle or an expansion of it that Walther Penck has in mind, but a step far in advance of Davis, an advance toward a deeper physiographic understanding of the processes of erosion on the surface of the earth. In discussing this point Professor Penck writes as follows:

> Let a comparison make the matter clearer. According to the Ptolemaic system of the universe, the planets move in cyclic orbits. To explain their retrograde motion epicycles are brought in. According to this method all planetary motions can be explained, but they only become comprehensible when we place ourselves with Copernicus—when we say that our standpoint, the earth, moves in a cyclic orbit just as do the planets. Their motions can only be calculated when we, with Kepler, conceive their orbits to be elliptical and apply his three laws to their motions. Certainly, each of the three great astronomers stands on the shoulders of his predecessors. But, for this reason, one will not, after all, call the Copernican system of the universe an expanded Ptolemaic system. In just the same way, the cycle theory, as my son develops it in his posthumous work on physiographic analysis, is not to be designated an expanded theory of Davis.

Four Bases of Criticism

There are at least four main lines of argument to be advanced in testing Penck's morphological analysis: (1) Except for the case of the so-called Mittelgebirge of Germany to which abundant reference is made, the chief illustrations are from front ranges or border ranges of far more extensive cordilleran highlands *within* which quite different conditions obtain. (2) The mobility of the earth's crust is one of the most striking features in Davis' development of the cycle idea, for it is constantly emphasized that the earth's crust is uneasy and that a vital part of a demonstration or explanation of land forms in a given region is the determination of the forms the landscape had in a prior state at a different level or in subyouthful stages during uplift. (3) There is a very curious lapse in Penck's bibliography in that the examples are very largely taken from German sources. A wholly inadequate reference is made to American literature in which the idea and applications of the cycle have been most thoroughly weighed and described. It is not merely that adequate reference is wanting. It is the far-reaching importance of the illustrations afforded by them that Penck does not take into account. (4) The fourth basis of criticism lies on the outermost fringe of the science of physiography today. It is that the relationship between isostasy and topographic form has not been determined with a degree of accuracy that enables one to put so fine an edge to an argument as Penck develops in his new study of topographic forms.

Types of Slopes and Their Origin

To support his main conclusions Penck begins by making a most elaborate analysis of the manner in which different types of slopes may come into being. Certainly in this respect his work is a contribution of the first order, and I can think of nothing comparable to it in this country except the analytical work done by the late Professor Joseph Barrell of Yale University. Everyone who has made extensive field studies in physiography must have become aware of the fact that our analytical equipment at the present time is not sufficiently well rounded. It is easy, as a rule, to explain the more picturesque and striking elements of a landscape. The direct relation between certain rock types and their corresponding slopes is not difficult to determine in many of the great mountains and canyons of the world. But when we analyze the old erosion surfaces now found in many parts of the world and in almost every important mountain system, we are confronted with difficulties of the first order. Adjacent fragments of old erosion surface are relatively easy of correlation, especially if such surfaces have been preserved from subsequent dissection by a capping of lava, as, for instance, in many of the mesas and fault-block mountains of the Southwest. On the other hand, if these surfaces be widely separated and without a protecting cap of resistant rock, they will be found in various stages of destruction (owing to different rock resistances, climatic conditions, elevation, etc.); and the fragmentary nature of an old erosion surface may leave doubt as to the correctness of any explanation based on former continuity.

It is precisely because there are so many unexplained physiographic features in existence that physiography continues to have the vigor of youth. I know of no adequate explanation, for instance, of the quite abrupt change in slope which one finds near many of the hilltops about the border of the White Mountains. The same abrupt break may be found at the foot of many residual masses in the central and less dissected portions of former all but base-leveled surfaces. Various elementary explanations have been offered for the marked difference in the character of slopes whether convex or concave to the sky—whether it is the variable rainfall, the varying resistance of the rocks, or the unequal depths of erosion that may be responsible, or what the effect is of changing combinations of all these and other factors. Intensive research upon such questions is needed in order to extend the area of explanation and to put a large portion of weakly descriptive physiography upon a rational basis.

Such an analysis Penck essays to make through the intensive study of selected examples and through a consideration of the manner in which stream profiles and valley-slope profiles change from stage to stage in the steady advance of erosion upon a given mass of rock. He believes that the orderly progression of forms through youth to matu-

rity and old age is the exception, not the rule. He concludes that uplift cannot be taken as a process in and by itself and erosion described as an event subsequent thereto. A very large part of his book deals with the relation of uplift to erosion. It seems to be his idea that Davis and other modern physiographers have assumed the movement of the land to be completed before significant erosion takes place. He would recalculate the rapidity of uplift and the rapidity of erosion of mountains in which old or mature forms are displayed. In the examples upon which his arguments are chiefly based (the front ranges of the Andean cordillera in northwestern Argentina) he accounts for the gentler slopes of the crest and upper flanks of the range not by erosion during a prolonged stillstand of the land and subsequent elevation to present mountainous height but, on the contrary, by that erosion which produced the very sediments that now flank the mountains and form the floors of the adjacent basins.

Penck claims to find through his detailed analysis of the mode of retrogression of the slopes of the land an explanation for the forms of old age independent of the idea of the cycle. Certainly he has brought into the literature a number of useful terms and has challenged prevailing explanations at a number of quite critical points. His recognition of the piedmont step; the brow of the uplifted block upon which an old erosion surface may be identified; the sharp topographic unconformity that exists between the old erosion surface and the residuals that rise above it and the remarkable localization of this last feature on a line almost as definite as a strand line; the importance of studying the effects of piedmont stripping upon an upland border where accumulation of sediments was made before an old erosion surface was developed upon the adjacent uplifted mass; the agencies which effect a change in the form of a landscape from concave to convex or from convex to concave; the constant challenge with which he meets a new grouping of forms—these are among the most important contributions of his book. A far-reaching influence is attributed to *intensity and degree of uplift* (as opposed to climate) in the modeling of slopes. If convex, the slopes are a response to rapid uplift; if concave, they bespeak a slower rate. Obviously the full test of the idea must come with the inspection of a far larger number of examples under the most divergent conditions.

There is no doubt that he has thrown out a most inviting challenge on page 238, where he questions the correlation of widely separated erosion remnants without the close analysis of their border phenomena which give a clue to their former position and also to their mode of origin. Such a challenge has often been made before but in most cases upon weak grounds. By organizing his detailed analysis in excellent form Penck greatly strengthens his position when he reaches the point where the larger conclusions and the larger physiographic interpreta-

tions are brought into consideration. Were his book translated and put into the hands of American students it would certainly lead to a profound stimulation in physiographic field work. Such stimulation is needed, for the detailed field studies now being made in the United States have reached the point where challenging questions are thrown out in ever increasing number.

Front-Range Physiography a Specialized Chapter

Having said this much, one may now return to the first of the four main criticisms of Penck's work as noted above. Front-range physiography is certainly a highly specialized chapter. It is unsafe to argue a revision of the whole science on the basis of the specialized phenomena there displayed. In this narrow belt are concentrated effects of change of level and of changes of climate whether these take place upon the plain or valley crustal block on the one side or the mountain block on the other. Moreover, there is here an overemphasis of the purely lateral attack of the streams. From the examples which he has studied in detail Penck concludes that a youthful stage of erosion may be initiated by uplift while the inner or more distant part of the mountain may continue to progress from an old stage to a still older stage. This is eminently possible if the inner part is uplifted without tilting, but it is startling to have such a statement put forward as a new discovery!

There is insufficient analysis of the fact that in the uplift of a broad cordillera or of a broad plateau there is never equality of uplift from district to district in a great region but a most involved and complicated result such as is shown in the Central Andes and in the Sierra Nevada. Faults and warps throw the older surface into new attitudes, and, however impressive the concentrated erosion of the main mountain borders may appear to be, no less impressive is the deep dissection of streams clear to their headwaters within the region, thus leaving undisturbed broad surfaces of erosion of earlier origin.

Basal sapping at the border, upon which Penck places such strong emphasis, has a special geographical position; it has no relation to that vastly larger number of cases where streams are invigorated throughout their entire length by a pronounced change in gradient as in the drainage systems of southern New England. A restoration of the older surface here shows a greater uplift in the more northerly sections, as, for instance, in northern Connecticut and more particularly in western Massachusetts. Basal sapping is a minor and almost negligible feature in the coastal belt. The successive profiles which Penck presents as the normal condition of changing stream profiles are inapplicable here. It is not near the southern border but in the

northern sections of the peneplain of southern New England that erosion has been most vigorous. The Deerfield gorge and related features are of a much higher order of importance than basal sapping on the margins of the peneplain. However complicated the physiography of southern New England may prove to be upon further analysis, and certainly it is much more complicated than the earlier and simpler statements would lead one to suppose, it is still true that the main episodes in that history are not difficult to understand, lengthy as the detailed explanations may be. In his attempt to harmonize the topographic cycle of mountain areas such as the Sierra de Fiambalá and the corresponding cycle of sedimentation in the adjacent basin floor, Penck has found a key not to systematic physiography as a whole but to that special chapter of it which might be called front-range physiography.

It is significant that there is no reference in Penck's bibliography to two papers by Louderback and Emmons.[6] Louderback has shown, by a most detailed study of the Humboldt Range in western Nevada, that the present mountain ranges and broad intermontane basins were produced by the differential movement of large crust blocks which rose or sank as units though not as absolutely rigid masses, since there are evidences of internal deformations of both faulting and warping on a moderate scale. Now it appears that, preceding the period of faulting and warping, there were great explosive eruptions from a number of volcanic centers and rhyolite outpourings covered large tracts of land. These lava beds followed the slopes of their time which were developed upon a complicated structure of anticlines and synclines formed in an early period of mountain making. The low relief which the region had in the period immediately preceding the period of faulting is not a matter of inference, of theory, or of guesswork. There the surface stands under the lava beds, preserved as it was when sealed up by the lava. Its low relief is no less in doubt than the low relief of the land surfaces exposed in the fifteen-mile section both at the top and the bottom of the Algonquin wedge in the Grand Canyon section.[7]

The next step in the argument may be briefly summarized. The lava beds are in many instances but little dissected, showing that uplift was sufficiently rapid to put them in their new position before significant erosion could take place. The resistant lava has limited

[6] G. D. Louderback: Basin Range Structure of the Humboldt Region, *Bull. Geol. Soc. of America*, Vol. 15, 1904, pp. 289–346; reference on p. 336.

W. H. Emmons: A Reconnaissance of Some Mining Camps in Elko, Lander, and Eureka Counties, Nevada, *U. S. Geol. Survey Bull. No. 408*, 1910, pp. 76–81 *et al.*

[7] Powell in the first instance described and explained the section, and Dutton elaborated the explanation. For a more analytical confirmation see W. M. Davis: An Excursion to the Grand Canyon of the Colorado, *Bull. Museum of Comp. Zoöl. at Harvard College*, Vol. 38 (Geol. Ser., Vol. 5), 1901, pp. 108–201. For a detailed study of later date see: L. F. Noble: Contributions to the Geology of the Grand Canyon, Arizona: The Geology of the Shinumo Area, *Amer. Journ. of Sci.*, Vol. 29, 1910, pp. 374–380.

erosion pretty much to the border of the range. From a study of the cliffed spurs that terminate on the straight line of the bounding fault one can even make out successive steps in the uplift of the tilted block.[8] When one passes to other fault-block ranges near by and discovers the same old topography not preserved by a lava cover yet readily identifiable though now deeply dissected, one is led to conclude that there is ample justification for treating the mountain range in just the simple manner that Penck supposes Davis uses on all occasions, that is, rapid uplift into its present position is a thing of greater importance than the amount of erosion that has occurred during uplift. In addition, there is here no question of warping because the topographic features have a demonstrated relation to faulting. While the argument at first depended upon a purely physiographic analysis of the blunt spur ends intermittently renewed, the broken alluvial fans across the valley mouths where they were crossed by the fault, and the slicken-sided rock surfaces on the edge of the upthrown block, we have long ago passed the point of inference and reached the stage of direct observation. This is the point in Emmons' paper, as will be seen by reference to his cross sections as actually observed in mines in the Bullfrog district, Nevada. It is a point made with equal force by Knopf in his studies of Inyo Range and the bordering Sierra Nevada.[9]

It seems impossible to escape the conclusion that Penck has overlooked the recognition of varying rates of uplift in the scheme of the cycle and has emphasized precisely the wrong things in his exposition. To take the case of the German Mittelgebirge again. He sees upon the rounded slopes and smoother surfaces of that region a progress toward a still more advanced stage of topographic development in which forms become gentler and flatter. But he sees at the same time the continued growth of youthful forms on the border of the area. Finally, he sees these youthful forms gradually replace the older forms of the interior. Thus he believes he has found a reversal of the normal sequence of erosion that takes place under conditions of uninterrupted activity. I cannot see why he considers this to be a discovery that requires the revision of physiographic science. Penck would have it that the Mittelgebirge are advancing to old age and then to youth, and Davis would merely put it that (having been in a stage of old age the surface is becoming older, to be sure, here and there) the significant thing is that the present elevation of the Mittelgebirge above sea level and its present relation to the bordering drainage lines will surely impose upon it in time a youthful condition such as Penck recognizes on the border and which he admits will extend its characteristics into

[8] W. M. Davis: The Basin Range Problem, *Proc. Natl. Acad. of Sci.*, Washington, D. C., Vol. 11, 1925, pp. 387–392.

[9] Alfred Knopf: A Geologic Reconnaissance of the Inyo Range and the Eastern Slope of the Southern Sierra Nevada, California, *U. S. Geol. Survey Professional Paper 110*, 1918.

the whole mass until finally the entire surface has again become youthful.

In such renewed dissection in headwater streams "youth" does not necessarily mean sharp ravines, since they deepen slowly and the valleys widen as they deepen. The result is to elide youth, as Davis has shown in his "Erklärende Beschreibung der Landformen." Typical young valleys, gorgelike, are characteristic of middle-course streams, where they have good height to cut down and good volume to cut down with.

If we take the case of the border ranges at the southern end of the Puna de Atacama as Penck has described them (pp. 212 to 216) one finds the significant statement on page 216 that the upper slopes are not fragments of a now all-but-dissected earlier relief nor that they have been elevated to their present position by some extraordinary uplift, but that their position depends upon the depth of dissection of the neighboring valleys and the resistance of the rock. But such an argument is altogether inadequate when applied to other regions even if we grant full competence to it in the front ranges of the southern border of the Puna de Atacama.

The next great steps in physiography may well be the application of Penck's argument to landscapes in critical or classical topographic regions and its use in the fuller discussion of cases of variable rates of upheaval which have been only briefly treated in earlier studies. When this is done it seems fairly clear that the idea of the topographic cycle as developed by Davis will still be the most important part of interpretative generalization. Combined with these in the ultimate analysis of the physiography will be the fundamentals of isostasy now just yielding to scientific treatment. Even then it will no doubt be found that topographic relations exist for which no satisfactory explanation may be found because they require too fine an edge of correlation. When that time comes it will be even clearer than now that a really scientific study of physiography is as much geological as it is geographical: as in Penck's subtitle, "a chapter in physical geology." It is not, however, a field that the geographer can neglect; for he must handle its elements with facility and real understanding if the feet of his "humans" are to remain on the earth.

AMERICAN GEOGRAPHICAL SOCIETY

Meetings of November and December. The first regular meeting of the American Geographical Society for the season 1925–1926 was held on November 24, 1925, at the Engineering Societies Building, 29 West 39th Street, President John H. Finley presiding. The Society was addressed by Dr. Alexander Hamilton Rice on the subject of his latest expedition to Amazonas and his surveys on the River Branco including its principal tributary the Uraricuera-Parima. By means of still and moving pictures and aerial photographs there were presented successive phases of the expedition in its ascent of the Branco and the headwater conditions in the foothills and toward the crest of the Sierra Parima. It is proposed to publish the first report of the expedition, the seventh by Dr. Rice to northwestern Amazonas, in the *Geographical Review;* and the maps will be reduced for incorporation in the sheets of the Millionth Map of Hispanic America now in preparation by the Society.

On December 22, Dr. C. U. Clark addressed the Society on Spain and Spanish Morocco, giving an illustrated account of the scenic and cultural features in the chief regions of Spain and the geographical setting of the problem of the Rif.

Elections to Fellowship. At the November meeting of the Society, President Finley presiding, there were presented with the approval of the Council the names of 551 candidates who were duly elected as Fellows of the Society.

Revision of the By-Laws. During the business meeting that preceded the lecture of November 24, notice was given of a proposal in writing that a general revision of the By-Laws be made; and it was announced that the revised text would be submitted in due form at a later meeting for consideration by the Fellows of the Society.

Distribution of Title Page, Contents, and Index of Vol. 15 of the Geographical Review. The title page, table of contents, and index for Volume 15 of the *Geographical Review* (1925), which is issued separately, is ready for distribution. Copies are sent to all institutions exchanging publications with the Society and to individuals who request that their names be put on a list for this purpose.

Announcement of the Society's Gold Medal Awards

The David Livingstone Centenary Medal to Luis Riso Patrón. Award of the David Livingstone Centenary Medal for 1925 for "scientific achievement in the field of geography of the southern hemisphere" is made to Luis Riso Patrón, Director of the Oficina de Límites of Chile in recognition of his contributions to Chilean cartography. Señor Patrón headed the first Chilean Commission to make a precise survey of the Cordillera of the Andes. He represented Chile in the Argentine-Chilean boundary arbitration (1902) and edited the maps of the Chilean boundary surveys. As director of the Oficina de Mensura de Tierras he was responsible for the great map of Chile on a scale of 1: 500,000. His intimate knowledge of the geography of his country is revealed in the recently published "Diccionario Jeográfico de Chile" (1924).

The David Livingstone Centenary Medal to Erich von Drygalski. Award of the David Livingstone Centenary Medal for 1926 is made to Erich von Drygalski of the University of Munich for his work in the South Polar regions. Dr. von Drygalski

had already carried out notable glaciological investigations in the Arctic as leader of the Greenland Expedition of the Berlin Geographical Society (1891–1893) when he undertook the German Antarctic Expedition of 1900–1903. The latter expedition, which discovered a part of the Antarctic continent about the 90th meridian east, was characterized by an intensive study of all branches of natural science in the field of exploration. The important scientific results in 18 folio volumes appeared between 1905 and 1921.

The Charles P. Daly Medal to Brigadier General David L. Brainard. The Charles P. Daly Medal for 1925 is awarded to Brigadier General David L. Brainard in recognition of his notable achievements on the Lady Franklin Bay Expedition under Greely in 1881–1884. General (then Sergeant) Brainard took a leading part in the exploratory work of the expedition. In particular his name is associated with Lieutenant Lockwood's in the discoveries along the north coast of Greenland when the farthest north of the time, 83° 24′, was reached, a position only a few minutes of latitude from the northernmost point of Greenland.

The Charles P. Daly Medal to Captain Robert A. Bartlett. The Charles P. Daly Medal for 1925 is awarded to Captain Robert A. Bartlett for his services to Arctic exploration. As commander of the *Roosevelt* (1905–1909) he took a leading part in Peary's expedition to the Pole. With a sledge party he himself reached a latitude of 87° 47′ N.—the highest latitude attained in the Arctic next to that of Peary himself. On the Canadian Arctic Expedition of 1913–1918 he commanded the *Karluk* and in the face of grave difficulties accomplished the rescue of the survivors from Wrangel Island, whither they had proceeded after the *Karluk* was crushed by ice. In 1917 under his able seamanship the Third Crocker Land Relief Expedition achieved success in the face of serious and exceptional ice conditions.

The Cullum Geographical Medal to Pedro C. Sanchez. The Cullum Geographical Medal for 1925 is awarded to Pedro C. Sanchez, Director of the Central Mexican Bureau of Geography and Climatology in recognition of his contributions to Mexican cartography. Señor Sanchez has been in charge of the geodetic service of Mexico since 1912. He is responsible for the topographic survey of the Federal District on the scale of 1:100,000; the map of the state of Vera Cruz, 1:400,000 (1918); and the Atlas Geográfico de la República de México (1920). He has also conducted explorations in little-known parts of his country.

The Cullum Geographical Medal to Harvey C. Hayes. The Cullum Geographical Medal for 1925 is awarded to Harvey C. Hayes, research physicist of the United States Navy for his invention of the Sonic Depth Finder. This instrument designed in the interests of navigation has put into the hands of science a practical means of mapping the ocean floor in detail and of furnishing data for more effective study of continent building and of the general problem of isostasy.

The Cullum Geographical Medal to Lucien Gallois. The Cullum Geographical Medal for 1925 is awarded to Lucien Gallois of the University of Paris for his work in the advancement of geography. His earlier studies established his reputation in the field of historical geography. His later work, embracing both physical and human aspects and finding expression in regional studies, furnishes an admirable exposition of the broad modern concept of geography. By his efforts as teacher, as collaborator and editor of the *Annales de Géographie*, and as president of the Association de Géographes Français, and especially by the spirit and method of his writings, his influence has carried far afield.

GEOGRAPHICAL RECORD

NORTH AMERICA

Rainfall and Populism in Kansas, Nebraska, and Dakota. Since the eighteen-eighties Kansas, Nebraska, and the Dakotas have been the home of radical economic and political movements. In this belt, Professor O. E. Baker writes, "settlement is still in progress, and systems of farming adapted to the varying geographic conditions are not yet fully established" (The Agriculture of the Great Plains Region, *Annals Assoc. of Amer. Geogrs.*, Vol. 13, 1923, pp. 109–167, reference on p. 110). Discouragement, failure, social and political discontent are logical results of the unstable adjustment thus suggested.

The populist movement of the late eighties and nineties had its roots partly in circumstances of national significance, but also in local economic and geographical conditions. The latter are discussed by Hallie Farmer in a recent study entitled "The Economic Background of Frontier Populism" (*Mississippi Valley Hist. Rev.*, Vol. 10, 1924, pp. 406–427). Among them rainfall was of fundamental importance. Miss Farmer asserts that the immediate cause of the collapse of the boom of 1880–1887 was the drought of 1887. Raymond C. Miller, on the other hand, writing on populism in Kansas, lays more emphasis on other economic factors, asserting that "climatic conditions . . . acted as the determining element only in the extreme western part of the state" (The Background of Populism in Kansas, *ibid.*, Vol. 11, 1925, pp. 469–489.)

Kansas, Nebraska, and the Dakotas lie astride the great climatic frontier between the arid west and humid east of the United States. Thus the eastern edge of Nebraska receives a mean annual rainfall of twenty-eight to thirty-two inches, whereas the western edge receives only sixteen inches. Like all climatic frontiers, this one moves back and forth, so that at any fixed point in its vicinity periods of drought follow periods of relatively plentiful rain. The early eighties were a moist period. Enticed by a vigorous campaign of advertising conducted by the railroads, real estate interests, and civic bodies settlers swarmed in. "The Kansas legislature provided for the organization of four counties in 1885, eleven in 1886, five in 1887, and three in 1888. Nebraska organized twenty-two counties between 1881 and 1888 and the legislature of Dakota territory created twenty-five new counties in the year 1883." Accompanying the increase in population was an enormous investment of eastern capital in mortgages, and also vast land speculation and no little fraud.

Then came the drought of 1887, followed by a decade during which there were only two years of normal rainfall. Crops were burned up by the hot winds, farmers went bankrupt, mortgages were foreclosed, many persons left their homes and moved away altogether, and the almost universal discontent among the farmers who clung to their farms or were bound to them by debt manifested itself politically in the People's Independent (or Populist) Party. Feeling ran high against the eastern capitalists, the railroads, and the middlemen, upon whom the blame for the hard times was placed.

A more detailed examination of the relation of rainfall to the populist movement in Nebraska alone is given by John D. Barnhart (Rainfall and the Populist Party in Nebraska, *Amer. Polit. Sci. Rev.*, Vol. 19, 1925, pp. 526–540). He studies the vote in the gubernatorial election of 1890 as regards the two main districts into which the state may be divided: the western, in which grazing on the whole is more successful than farming, and the eastern where farming is the more important. The

line dividing these districts corresponds roughly to the twenty-inch isohyet, although the sand-hill region carries it well to the east of the latter in the north-central part of the state. During the eighties the impression gained ground and was even expressed in official documents that the rainfall was not only adequate for farming but was increasing throughout the state. Settlers advanced beyond the critical agricultural and climatic frontier. Then in 1887 began the decade of drought and hard times. The election returns of 1890 show the highest percentages of Independent votes in a strip of counties lying along the agricultural frontier—that is in the recently settled farming region which had been hit hardest by the drought. The more rainy and prosperous east and the pastoral west show relative low percentages of Independent votes. "The lack of rainfall was not as serious in its effects upon the wild grasses of the range country as upon the crops of the cultivated region." Considering the data as a whole, Barnhart concludes cautiously that "the drouth was one of the significant local causes affecting the Independent movement."

There is another type of economic and climatic frontier, separating grazing country from true desert. This often corresponds approximately to the ten-inch isohyet. Premature attempts to carry settlement beyond it may be as disastrous as the premature advance of farmers beyond the drought limits of unirrigated agriculture (for an Australian example, see the present number of the *Review*, p. 165).

Altitude and Settlement in North America. To what extent are the settled parts of North America separated by uninhabited tracts, and to what extent do these tracts foster sectionalism and constitute a menace to national solidarity?

With a view to answering the first of these questions and to providing a clue toward the solution of the second, Alfred Weihl sets forth some observations in a recent article (Die Höhengrenzen der Besiedlung und der Landnahme in Nordamerika, *Geopolitik*, Vol. 2, 1925, pp. 560–575). He studies particularly the upper limits of settlement and of the occupation of land. Tables and maps illustrate the maximum altitudes of agricultural, pastoral, and mining settlements in the different mountain ranges of the continent.

As a general rule, the upper limit of settlement rises as you go from north to south. There are, however, many local variations due to differences in position, topography, climate, and vegetation. For example, in the Great Basin the extreme dryness of the mountain tops fixes the limit of agricultural settlement at a considerably lower elevation than in the Rockies. Settlements tend to cluster where valleys open out on alluvial fans fringing the intermont basins. In the valleys of the Olympic Peninsula, rough topography and thick forests, due to an excessively heavy rainfall, keep the limit down to 1000 feet. In some ranges there is asymmetry between the maximum altitudes of settlement on opposite sides. On the eastern slopes of the northern Sierras pasture lands run to a height of 6430 feet, whereas on the western side they reach merely to 6030 feet. The highest agricultural settlements in the United States are in central Colorado, near Leadville, at elevations of 10,000 feet. (Dr. O. E. Baker mentions crop growing, potatoes and barley, at 10,000 feet about Snowflake, Ariz.).

In conclusion, Weihl shows that if we regard the western part of the continent as a whole, the unsettled areas form isolated patches. The most extensive of these lie, of course, in Alaska and Canada, though there are also large tracts in Mexico. In the United States, only high mountain masses are still wholly unoccupied. "Settlement in the arid basins and plateaus has already been carried far enough to bind the east firmly to the Pacific coast."

The Revolution in Transportation. The invention of the gasoline motor is producing throughout the civilized world—and particularly in the United States—a series of changes, economic and geographical, comparable to the changes wrought nearly a century ago by the railroad. Toward meeting some of the crucial problems

to which this pacific revolution is giving rise in New England, a conference was held in Boston, December 8 and 9, 1924, at which the creation of a permanent New England Transportation Council was authorized. The addresses delivered before the conference have been published in a brief but suggestive pamphlet (Place of Train, Trolley, Truck and Bus in New England, *Natl. Automobile Chamber of Commerce [Publ.] No. 205*, New York, [1925?]).

The Boston & Maine R. R. is "giving serious consideration to what can be done in the way of working out the transfer of unprofitable short haul traffic to the truck lines." The New York Central R. R. is using trucks of its own for certain special types of haul. In the passenger field, railway men recognize that while the street railway is more economical for mass transportation, the bus, with its flexibility, "brings life to undeveloped yet accessible territory and tends to enlarge and accentuate the entire transportation activity in a given area." The further problem as to who shall be granted franchises for the operation of bus lines, free lance companies or the railroads, is a burning political issue in many American communities.

The effects of the revolution in transportation in the cities is particularly interesting to the student of urban geography. So much of the freight and passenger traffic that the railroads used to handle has now been diverted to the city streets, that one authority says: "our cities are merely terminals of our highways and are subject to the same troubles that beset a railroad terminal." The regulation of the immense and rapidly increasing automobile traffic can be met partially by police measures. For example: "when intown traffic is heavy, in the morning, [it would be possible to establish] one outbound line and as many inbound lines as there is room for. This can be reversed for the homeward-bound rush." But the final solution will probably be found only in the realm of city planning: in decentralization, involving "the driving of business from our city centers."

Chicago Highways, New and Old. The use of the motor truck on the highways of a region as well served by railroads as that of Chicago is a striking development of the last ten years. The number of paved roads and the congestion of the railroads have brought the truck into prominence and, with it, an increasing commercial use of the highways. In the Chicago region, this development is particularly true with reference to dairy products. Thirty-two per cent of the Chicago daily milk supply, produced in northeastern Illinois, southern Wisconsin and northwestern Indiana, is brought to the city by truck. The growth of Chicago and its suburbs has crowded the dairy farms back until delivery by wagon is no longer possible. Motor trucks have taken the place of wagons and, within a radius of fifty miles, have to a large extent superseded the railroads. Truck service has the advantage of passing the producer's gate, of reducing the number of handlings often from a half dozen to two, of losing fewer cans, and of saving about five cents a hundredweight on the haul from the railroad platform to the city milk dealer. Drawbacks are encountered in the condition of the roads at certain times of the year. An article by E. L. Browne entitled "Transportation of Milk by Motor Truck in the Chicago Dairy District" (*Public Roads*, July, 1925, pp. 107–115), goes thoroughly into this modern use of the Chicago highways and is accompanied by informative diagrammatic maps.

Many of the present-day truck routes follow the early roads on which commerce moved before the advent of the railroads. The position of Chicago at the junction between water travel from the east and land transportation to the west caused its location and later prosperity to be linked intimately with its highways. The roads, or "traces" as they were then termed, were popular with the pioneer in the autumn when the land was drier, fords less deep, and food comparatively more plentiful. The Chicago Road, following an earlier Indian trail from Detroit, and the Vincennes Trace, linking the Wabash River with Chicago, were two important thoroughfares from the east. Of those leading northward and westward, the Green

Bay Road, an early connection between military posts; the roads to the Galena lead mines in northwestern Illinois; and the Ottawa Road, following the Desplaines River, were the most important. Travel was exceedingly difficult as there was no attempt at draining or surfacing any but a few plank roads. The story of these early roads and of the joys and sorrows of travel on them is told by M. M. Quaife in "Chicago's Highways, Old and New" (D. F. Keller & Co., Chicago, 1923), a book which provides an enlivening background for the geographical student of the existing network of highways in and about Chicago.

Highways of California. Highways are of prime importance to a state which exploits its climatic attractions and scenic beauties in the manner of California. This is shown by the recent "Report of a Study of the State Highway System of California" by the state Highway Advisory Committee. While most of the report is devoted to the usual discussion of constructed highways, proposed additions, maintenance, and financing, a series of accompanying maps presents some illuminating relationships between population and traffic densities. The map of the density of traffic on the state highways indicates that the Pacific Coast Highway and the road traversing the Sacramento and San Joaquin valleys are the most important. The fact that the traffic is principally confined to these two routes which either fail to reach the northern and southern boundaries or do so with a great loss of traffic, strongly emphasizes the isolation of California as far as automobiles are concerned. Intercity traffic, far more important than interstate, is yet much less vital than the traffic of the urban centers of San Francisco, Sacramento, and Los Angeles. The correlation of this map with that of population density is striking. The latter has been drawn with the township as the areal unit and consequently gives a more exact location of the population than the more usual county-unit maps. The intensive concentration of population about San Francisco and Los Angeles, as well as a secondary concentration in the California Valley, is clearly shown.

SOUTH AMERICA

Plans to Facilitate Traffic on the Magdalena River. The government of Colombia is making serious efforts to facilitate transportation between Bogotá and the outside world. By far the greater part of merchandise consigned to Bogotá is unloaded on the wharf at Puerto Colombia, carried by rail to Barranquilla, and there loaded on river steamers which carry it up the lower Magdalena to La Dorada. From there it is carried by rail around the rapids of the middle Magdalena to Beltrán when it is again loaded into steamers which carry it up the upper Magdalena to Girardot.

The air route for passengers established between Barranquilla and Bogotá has been a boon to business men, but the rates put this means of travel beyond the reach of the average travelers, many of whom prefer to make the trip by mule back from Zarzal or Cartago to Ibagué—an arduous but much shorter trip than by the Magdalena River route.

The railway aspects of the problem are discussed elsewhere in this number of the *Review:* we shall here refer to difficulties connected with the Magdalena as a waterway. During the dry season there are often periods of from six weeks to two months when traffic on the lower Magdalena is practically stopped or at least reduced to a matter of moving from sand bar to sand bar as the level of the river is raised for a short period by a rain storm in the upper reaches of some of its tributaries. In flood season the current of the river is such that anywhere from three to five weeks may be required to work the steamers upstream against it. Sediment and current so change the course of the navigable channels from season to season that with the most skillful pilots and even in times of high water there are frequent delays while the steamer

is being worked off the bank. The great quantities of vegetation and more particularly the uprooted trees brought down into the main stream by the tributaries are a constant menace to traffic. All during the high water period the passenger on the river boats of the lower Magdalena is struck by the continuous wearing away of the banks. On the outside of the meanders of the rivers there is a constant breaking away of great masses of soil and vegetation and a steady toppling of forest trees over into the current. (For details of the tributaries of the middle Magdalena, see Otto Stutzer: Geographische und geologische Beobachtungen an Flüssen und Bächen des mittleren Magdalenentales in Kolumbien, *Petermanns Mitt.*, Vol. 71, 1925, pp. 63–67.) When the banks of the upper and middle Magdalena and the tributaries were well forested the run-off was so checked that the period of very low water was comparatively short; but until recently, when oil-burners have been installed on the express boats on the lower Magdalena, wood cut from the forests along the bank was the only fuel used, as it still is in the upper Magdalena and on the navigable tributaries. Today, except along the lower reaches of the Magdalena where there has been but little cutting because of the swamps and the poor quality of the trees for fuel purposes, one sees great areas completely deforested.

A German firm has made a careful survey of the whole river from Neiva to Barranquilla by airplane photography and triangulation and has submitted a report to the government on the canalization of the rapids of the middle Magdalena and on the canals, dikes, and dams needed to control the stream and keep it open to navigation at all seasons. The experts employed by this firm made an exhaustive study of the topography, geology, rainfall, and vegetation of the region immediately bordering on the river; of the depths, currents, and volume of the river itself at different seasons; and of the volume of water and the amount of sediment brought down to the main stream by its tributaries at different seasons. The report also includes studies of the volume of traffic on the river and of the mineral and agricultural resources of the country which have their natural outlet by way of the Magdalena. The government plans to publish the greater part of the report. It will form a notable contribution to the knowledge of the geography of the region. Proof that the government at Bogotá seriously intends eventually to carry out some project of control of the river is seen in the fact that a contract has recently been made with an American firm for the development of the port of Barranquilla (Boca de Ceniza: Mouth of the Magdalena River, *Bull. Pan Amer. Union*, Vol. 56, 1923, pp. 331–343).

AFRICA

The Completion of the Sennar Dam. In July last the great barrage at Makwar, near Sennar on the Blue Nile, work on which was begun in 1912 but interrupted by the war, was opened and water for the first time allowed to flow into the new Gezira irrigation project (*African World*, September 12, 1925, p. 261; *Near East and India*, September 24, 1925, p. 391). These events marked an important step forward in the movement now in progress toward the promotion of cotton cultivation within the British Empire, a movement in response to rising prices due to the ever increasing consumption of American cotton by the American textile industry (see W. H. Himbury: India and the Sudan as Sources for Increasing our Raw Cotton Supplies, *British Cotton Growing Assn. [Publ.] No. 81*, July, 1923: Général Helo, Le coton au Soudan égyptien, *La Géographie*, Vol. 40, 1923, pp. 574–584).

The new Sennar dam is twenty miles long and creates a reservoir with a holding capacity approximately equivalent to that of the Ashokan reservoir, which supplies New York City. Of a total of 300,000 acres which can be irrigated from this source, about 80,000 acres were to be planted in cotton in 1925, this area to be increased in 1926 to 100,000 and ultimately to 150,000. Objections have been raised by Egypt to

the diversion of Nile water for purposes of irrigation in the Sudan. The matter was under investigation in 1925 by an international Nile Irrigation Commission, the report of which is not as yet available. It is estimated, however, that no less than 3,000,000 acres in the Gezira (or "island" between the Blue and White Niles) are capable of successful cultivation under irrigation. (See also R. W. Allen: Irrigation in the Sudan, *Journ. African Soc.*, Vol. 23, 1924, pp. 257–264.)

The Decline of White Population in the South African Midlands. "If the White race is to hold its own in South Africa it will be necessary to secure an immense development of White civilization during the next fifty years or, perhaps, only the next twenty-five years." Thus the report on the last (1921) census of the Union of South Africa. The retardation of rate of increase for the Union as a whole during the last decade is "too significant to be ignored." Specially significant is the decline in the midlands. The white population of the vast Karroo-Cape Central region (see the accompanying map) increased only .77 per cent between 1911 and 1921; 25 of its 38 districts record decrease of rural population from over 8 to over 28 per cent. It cannot be explained entirely by fortuitous happenings such as the influenza epidemic of 1918 or by the northward trend of population. It has been in evidence since 1891 and has been steadily spreading; areas in the south and west Orange Free State are affected as well as Cape Province. There has been a general growth of town population at the expense of the country and an alarming increase in the numbers of the "poor whites." In the affected area, primarily a region of small stock farming, the number of stock has also decreased very considerably. That this indicates an actual decline in productivity of the land was demonstrated by the Drought Commission in their interim report (see "The Drought Problem of South Africa," *Geogr. Rev.*, Vol. 13, 1923, p. 307). The final report, an analysis of which is now appearing in the *Journal of the Department of Agriculture* (Pretoria), confirms the seriousness of the situation, the decline in stock-carrying capacity through deterioration of the vegetal cover and soil erosion.

Contrary to what might be expected the semiarid area of the northwest of Cape Province shows increase in population. Here stock are limited by the water available rather than pasture. "It would seem, indeed, that by providing less water in the North-West, nature has prevented the farmers there from over-stocking their farms, and so, perhaps, has saved them from themselves." Gain in the northwest has been made possible by railroad extension and irrigation development; but population here is still scant, about one person to two square miles.

The chief gains for the Union have been made in the industrial areas of the coast and in the Transvaal. In the latter the districts comprising the Witwatersrand account for 50 per cent of the increase for the whole province. For the Union as a whole the proportion of urban population is now 56 per cent.

Rainfall of Uganda and Kenya. A new map of the annual rainfall of a large part of east central Africa has recently been made by Mr. C. E. P. Brooks (The Distribution of Rainfall over Uganda, with a Note on Kenya Colony, *Quart. Journ. Royal Meteorol. Soc.*, Vol. 50, 1924, pp. 325–338). It is based on the records of 51 stations in Uganda and 70 in Kenya Colony. The average period for the Uganda stations is but 10 years, and the stations are so scattered that no attempt was made to reduce them to the same period of years. The variation of annual rainfall is so large, the wettest years having about twice the rainfall of the driest, that the distribution as mapped is recognized as but a preliminary indication of the true one. The average total fall in Uganda varies from 31 inches in the southwest to 76 on the west shore of Lake Victoria and 71 on the slopes of Mt. Elgon northeast of Lake Victoria and east of Lake Kioga. In Kenya the rainfall is over 50 inches on Mt. Kenya and some other highlands, locally under 30, and north of Kilimanjaro under 20. Along

CHANGES IN WHITE POPULATION, 1911-1921

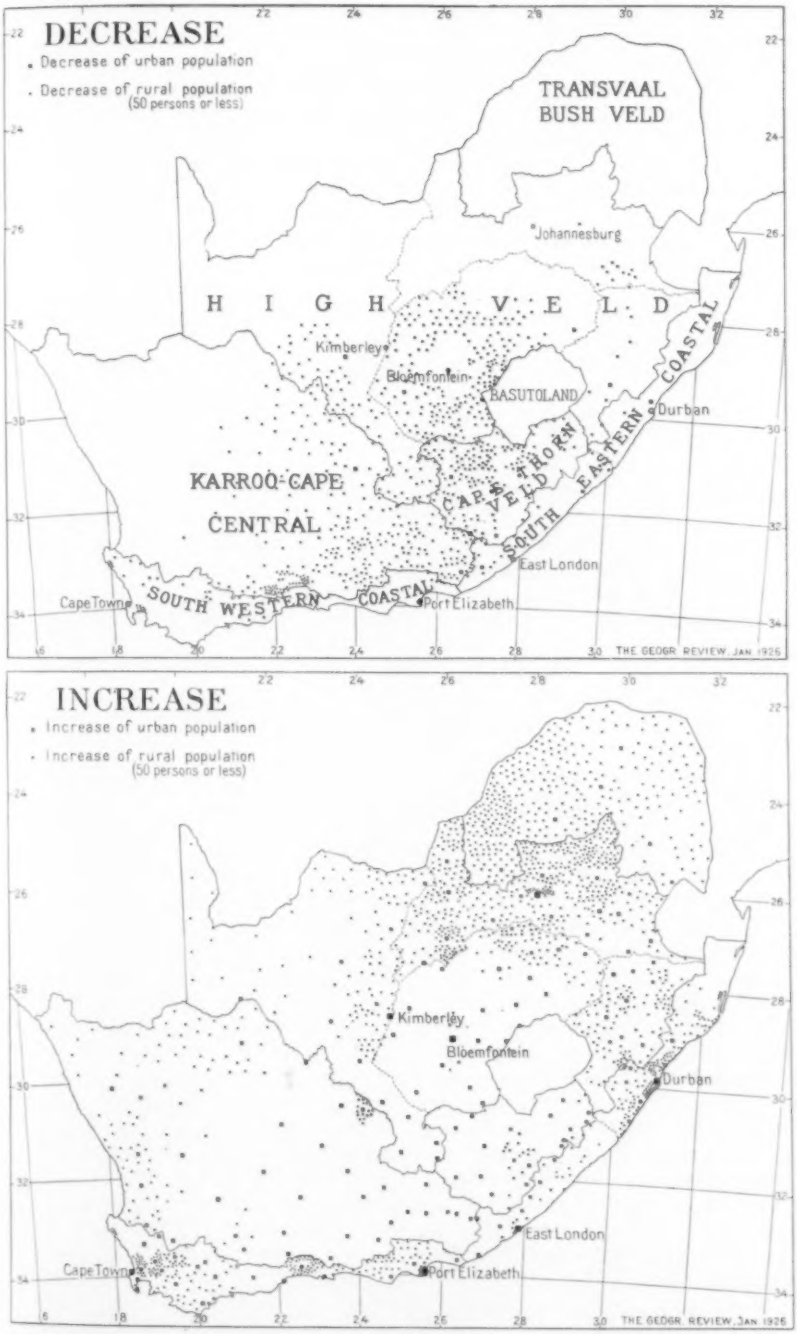


FIG. 1—Decrease and increase of white population between 1911 and 1921 in the Union of South Africa, drawn from maps accompanying the official census report. Regional subdivisions (named in the upper map) shown by solid, political divisions by dotted, lines.

the coast from latitude 2° S. to 5° S. the rainfall is about 40 inches, but near the equator it is only 15 inches.

For Uganda Mr. Brooks presents maps of the percentage distribution of rainfall by seasons and a diagram showing the same by months by latitudes. The progress of the equatorial rainy belt northward in spring and southward in fall is evident. The equatorial double rainy seasons tend to merge beyond latitude 5° N. and to draw together at latitude 2° S. The spring rainy season is much more pronounced than the autumn one. From the equator southward the peak of the rainy season following the sun returning from the north is delayed till two or three months after the equinox. In both Uganda and southern Kenya April is by far the wettest month.

The number of rainy days averages from 72 to 160 a year in Uganda. The heaviest falls in 24 hours rarely exceed 5 inches, though 7.45 and 7.00 inches in a day have been recorded. At Nairobi 3.30 inches once fell in 50 minutes. Hail is occasionally experienced.

CHARLES F. BROOKS

Sun Spots and Variation in the Levels of the Central African Lakes. Another illustration of the effects of solar variation on the weather has been supplied by C. E. P. Brooks in a study of "Variations in the Levels of the Central African Lakes Victoria and Albert" (*British Meteorol. Office Geophys. Memoirs No. 20*, 1923). Over a period of about 25 years, or two sun-spot cycles, the levels of these lakes have varied closely in accordance with sun-spot numbers, but the immediate causes of this correspondence prove difficult of establishment. The observed fluctuations of 70 inches in the surface level of Lake Victoria and of 160 inches in that of Lake Albert come primarily as a result of the lack of balance between receipt and loss of water, though there may be some errors in the reported levels of the lakes; and the levels as observed at only one place on the shore of each lake may not represent the general levels of the lake.

The rainfall of the region seems primarily responsible for the variations in level, there being a correlation coefficient of 0.195 between the rainfall of the lake plateau and the level of Lake Victoria (P. Phillips, *Nature*, Vol. 113, 1924, pp. 440–441; see also C. E. P. Brooks: The Fluctuations of Lake Victoria, *Journ. East Africa and Uganda Nat. Hist. Soc.*, June, 1925, pp. 47–55). The correlation coefficient of sun spots and rainfall is 0.64. The consecutive occurrence of rainy days is apparently of considerable importance, for a string of rainy days will produce a larger net supply of water for the lake than will disconnected rainy days with the same amount of rainfall (A. J. Henry, *Monthly Weather Rev.*, Vol. 52, 1924, pp. 151–152). Mr. Brooks claims that the amount of evaporation is highly important as a factor in the periodic changes in the levels of these central African lakes. The apparent influence of the sun spots is not nearly accounted for by the observed variation of lake levels with the rainfall. Furthermore, the outflow appears to be so small and so nearly constant that changes in evaporation must be coördinate with changes in rainfall in controlling the levels. Mr. Brooks computes the outflow from Lake Victoria as but 6 per cent of the receipt of water directly by the 26,000 square miles of lake surface and by run-off and seepage from the 66,000 square miles of drainage area.

Professor Henry doubts, however, that evaporation is a considerable factor in the large fluctuations in levels. There is no direct evidence that the evaporation varies systematically with the number of sun spots; and the data on outflow are too uncertain (discussed in full, with reply by Brooks, *ibid.*, pp. 148–153).

Whatever may be the relative importance of rainfall and evaporation, and however these changes may be controlled by the solar variations, there is no question that Mr. Brooks has pointed to a very striking correspondence between lake levels and sun spots.

A close sympathy between lake level and sun-spot numbers has also been observed in the case of Lake Nyasa (F. Dixey: Lake Level in Relation to Rainfall and Sunspots, *Nature*, Vol. 114, 1924, pp. 659–661). Minimum of the lake occurs with sunspot minimum as in the case of Lake Victoria. This was well seen in the drought period 1911–1912. During this low-water period the exit of Lake Nyasa, the Upper Shire River, was choked by sediment and vegetation, thus introducing a complicating factor in the cycle of lake-level variation.

CHARLES F. BROOKS

ASIA

Geography and Boundaries at Mosul. At the close of the World War the Mosul district became a center of intense rivalry because of the oil fields included in it as well as the wealth and general trade in products of flocks and fields. The rival claims of France and Great Britain with respect to oil affected the drawing of the eastern boundary of Syria and the northern boundary of Mesopotamia, and this difficulty was partially resolved only to be in turn overshadowed by the conflict between the new state of Iraq formed out of Mesopotamia and the government of the Turkish Republic. The territory in dispute has an area of nearly 87,890 square kilometers and a population exceeding 800,000. Supporting the claims of the kingdom of Iraq were British political and economic interests as well as British responsibility for the new state under the terms of the mandate received by it from the Council of the League of Nations. There followed protracted negotiations at Brussels, before the Council of the League at Geneva, and at Constantinople; and the net result of these was the appointment, by the Council of the League, of a commission consisting of three members and including among them Count Paul Teleki, a geographer of distinction and former Premier and then Foreign Minister of Hungary.

The commission executed its field work and prepared its report in the winter of 1924–1925; and the report, with maps, has now reached this country. From the geographical point of view no less than the political and historical the document is of the greatest interest. There is a detailed analysis of the relief and drainage as well as the ethnographic constitution, density of population, religion, routes of trade, natural economic districts of the Mosul region, and the winter and summer quarters and routes of migration of Kurdish nomads. The report is illustrated by the British War Office map of 1925 on the scale of 1:1,000,000, showing in color the relief, drainage, roads, and towns of the region, and by 10 other maps showing the geographical distributions mentioned above. Almost every technical refinement of argument was employed by both British and Turkish experts in making out their respective cases for an extension of frontiers to include Mosul. These types of argument, including the strategical and economic, were employed again and again during the Peace Conference and since that time in other disputed questions, and the present report loses nothing by comparison with its predecessors in other fields. It exhibits a very high level of skill not only in the manner in which the Commission presents the alleged facts of geography and history but in the quotations that are given from the opposing arguments of the British and Turkish authorities. The conclusion is reached that the so-called Brussels Line and the British line north of Mosul are better strategical frontiers for the protection of that city and region than lines selected by the Turks farther south. Turkish argument in favor of a plebiscite is not accepted by the Commission in view of the feudal organization of the inhabitants and the impossibility of obtaining a free expression of popular will. There is a most interesting analysis of the trade of Mosul, which is shown to be of more importance in its relations with Baghdad and Basra to the south in the state of Iraq than with Anatolia toward the north or Syria toward the west. The striking fact is brought out that the Kurds are rapidly diminishing in numbers, their tribal organizations

having been largely broken up and the population decimated by the great Russian invasion from the north during the World War, an invasion which came in a particularly hard winter season. This in a measure simplifies the boundary problem because it diminishes the force of the argument that a northern boundary such as is claimed by Iraq and the British would break across the lines of migration of Kurdish and other nomadic tribes.

Turkey however refuses to accept the report of the Commission as fair and insists upon a plebiscite. The possibility of war is therefore troubling the Council of the League of Nations. The Commission itself is of the opinion that unstable Arab rule in Iraq is bound to continue for the greater part of a generation and that if the British Mandate is to cease it would be better to give the Mosul district to Turkey. That it may cease in 1928 is a possibility, for between Iraq and Great Britain there is a treaty of alliance which was signed in September, 1924, and which is to be in force for four years; and this treaty has been accepted by the Council of the League of Nations as the form which the mandate is to take. When the treaty was ratified by the Iraq parliament there was adopted a concurrent resolution to the effect that it should become null and void if the British government failed to safeguard the interests of Iraq in the vilayet of Mosul.

Every geographer should supply himself with a copy of this report while it is available because it is the best illustration of the importance of geography in boundary settlement that has been furnished under official auspices since the close of the World War.

The Strategic Situation of Singapore. "This is by far the most important station in the East; and, as far as naval superiority and commercial interests are concerned, of much higher value than whole continents of territory." Thus Sir Stamford Raffles wrote of his four-months-old colony of Singapore in 1819. It was no fantastic vision. From the first the settlement prospered. In little more than three years it rose from an insignificant fishing village to a town of "at least 10,000 inhabitants of all nations." Today with a population approaching a half million Singapore is one of the world's foremost ports; in Asia it is exceeded in tonnage of shipping only by Hongkong and Colombo. In 1924 there was exported from the Straits Settlements $212,855,000 worth of Para rubber and $169,177,000 worth of tin. The make-up of the population is interesting. In Singapore Settlement at the 1921 census less than 14 per cent of the population was Malay: Chinese formed 76 per cent, Indians 8 per cent. Tin and rubber in adjacent territories, miners and plantation workers recruited from those areas of swarming population east and west have contributed to the rise of Singapore; the rest has come in the main from its focal situation south of the turning point of Asia. This situation makes of the Lion City not only an entrepôt but a strategic center. Whence arises the current interest in Singapore as a naval base. The present situation and its preceding history are discussed by F. W. Mohr in a paper "Singapore" in the October number of *Geopolitik* (pp. 741–758). The relation of Singapore to Australia, the Philippines, and Japan is elaborated, and stress is laid on the oil resources of the adjacent regions.

This matter of strategic situation is discussed in an illuminating way by Vaughan Cornish in a paper entitled "Singapore and Naval Geography" (*United Empire*, August, 1925, pp. 500–512). To realize its significance a new orientation of the map is needed. He illustrates with two maps. One on Mercator's projection has 110° E. as the central meridian. On it can be shown without interruption communications between the Asiatic and Australian coasts of the Pacific west to Europe, east to America. The break comes at 70° W., a line about which the fleets of the naval powers ordinarily turn their backs. The meridian 110° E. traverses centrally the East Indian Seas whose intricate channels connect the Indian and Pacific Oceans. As the now famous "Washington Line," east of which apply the territorial restrictions imposed by the Treaty of Washington (1922), the 110° E. meridian has ac-

quired a special strategic and political significance. Singapore lies 370 nautical miles west of the line and with its equatorial latitude thus occupies a central position on the map.

With this same orientation in mind one may divide the globe into eastern ("East Indian") and western ("West Indian") hemispheres centered respectively on the 110° E. and 70° W. meridians. The key situation of Singapore is emphasized. On one of the world's great commercial and strategic routes; on the air-line from India to Australia; a pivot for the British fleets of the East Indian, China, and Australian stations, Singapore lies at the heart of the East Indian hemisphere. Much of the argument regarding Singapore as a naval base has turned simply on its relations to the Pacific: this is an unbalanced view of the strategic geography, says Vaughan Cornish, for it ignores the vastly important relation to the Indian Ocean.

Aerial Survey of the Irrawaddy Delta Forests. The tidal forests of the Irrawaddy have long been a valuable source of timber and fuel for the rice-growing regions of the delta. Back of the worthless mangrove swamps that fringe the creeks are stands of almost pure *kanazo*, the most valuable tree. To protect against undue exploitation Government Forest Reserves were established in 1895–1901. It has long been desired to map their resources, but an adequate base was lacking. The terrain is one that offers peculiar difficulties to the topographer—a flat plain of soft shifting mud, largely awash at spring tides, cut between the main distributaries by a maze of creeks winding in all directions. The *Kanazo* itself flourishes best on land flooded daily by the tide but where the waters disappear completely from the surface for several hours between tides.

How the problem has been met by the authorities is described by Messrs. Kemp, Lewis, Scott, and Robbins in "Aero-Photo Survey and Mapping of the Forests of the Irrawaddy Delta" (*Burma Forest Bull. No. 11*, 1925). Their work is also discussed in a paper of similar title by L. Dudley Stamp in the *Journ. of Ecology* (Sept., 1925, pp. 262–276). Interesting photographs accompany both publications.

In general the important vegetational types were easily distinguished in the aerial photographs. The gregariousness of the species proved a great help, as also did the flatness of the terrain, light and shade effects being governed solely by differences in the vegetation. The photographs were taken between 10 a. m. and 3 p. m. so that the narrow creeks should not be obscured by shadow. For stock mapping an hour when the sun was low would have been preferable, and oblique photographs at a low elevation would have furnished useful supplementary data for interpretation. With all considerations in view, including cost, an altitude of 8000 to 10,000 feet proved best for flying. The survey covered 1440 square miles all told, and the work was completed in a few months where it was estimated that a ground survey would have taken three to four years.

AUSTRALASIA AND OCEANIA

Samoan Weather and Its Bearing on Periodicity Studies. Since 1921, after the award of the Samoan mandate to New Zealand, the Apia Observatory has been maintained jointly by the government of that country, the British Admiralty, and the Carnegie Institution of Washington. For thirty years previously meteorological observations had been made by German observers at Apia. Their results have now been reduced by Dr. Angenheister, late director of the observatory, edited by E. Marsden and D. M. Y. Sommerville, and published by the New Zealand authorities. The material thus made available offers some features of special interest.

The Samoan Islands lie isolated in a wide tropic ocean, in an environment of great climatic uniformity. "The amplitude of the yearly variation of air-temperature on

the open ocean up to 1,000 m. altitude is about 1° C. only. The daily variation is very small, or even vanishing altogether near the surface on open sea. The air-pressure shows a very small and regular annual variation of 3 mm. The daily pressure-variation, mainly semidiurnal, is of astonishing regularity. The year is distinctly divided into a dry and a wet season. The wind on open sea blows as an easterly trade wind day and night during the dry season for about 87 per cent, during the wet season for about 68 per cent of the time."

The Apia Observatory itself, close to the shore and well exposed to the trade winds, exhibits the homogeneous maritime climate to a high degree. The Carnegie Institution reports that special new instruments have been designed for recording the low range in temperature and pressure. The very small amount of daily, annual, and irregular variations in the climatic elements make it possible to detect small periodic fluctuations more readily than in other more disturbed stations. The eleven-year period is hardly anywhere better developed. At sunspot minima the temperature is ¾ of a degree (C.) higher, the pressure about ½ millimeter lower, and the trade wind at noon 10 per cent less frequent than at the maxima. The three-year period also is well marked. High and low pressure waves of this period can be followed across the southern hemisphere. These waves "seem to start from South America progressing both east and west from there. Stations of 180° difference in longitude are approximately in opposite phase. This should give rise to an asymmetrical pressure on the axis of the earth's rotation, and thus to a change of position of this axis."

A preliminary analysis of the atmospheric tides also shows a remarkable regularity.

POLAR REGIONS

The Political Geography of the Arctic. In a paper "Political Rights in the Arctic" (*Foreign Affairs*, October, 1925, pp. 47–60) David Hunter Miller analyzes the legal status of Arctic lands, known and unknown. The sovereignty of practically all the known Arctic lands is either definitely established or definitely claimed. The chief exception is Franz Josef Land, which does not seem to be the subject of positive claims, though from its situation it will be claimed presumably by Russia.

Norway's claim over Spitsbergen and Bear Island, henceforth to be known as Svalbard, was recognized by most of the Powers in 1920 and formal annexation took place on August 14, 1925.

Danish titular sovereignty over Greenland was generally recognized in 1919. In 1921 Denmark issued an official circular closing all of the country to other nationals. Subsequently Norway protested against this action, and by treaty of July 28, 1924, Denmark opened East Greenland to Norwegian traders, sealers, and whalers and agreed to postpone final decision 20 years, during which time the two nations would enjoy equal opportunity of establishing commercial influence in that part of the country. Exception was made of Angmagssalik and of a tract about Scoresby Sound provided it be populated by Greenlanders. Steps towards such occupation have already been taken. A preliminary voyage was undertaken by Ejnar Mikkelsen in 1924, and colonists were carried thither in 1925 (Ejnar Mikkelsen: A Summer Voyage to Scoresby Sound, *Amer. Scandinavian Rev.*, January, 1925, pp. 21–28; *idem:* Ekspeditionen til Scoresbysund med Formaal at forberede Koloniseringen, *Geogr. Tidsskr.*, September, 1925, pp. 152–170). A concession similar to that for Norway was made to Great Britain in 1925.

Russian claims in the Arctic do not appear to be precisely set forth. In 1916 Russia gave notification that various islands adjacent to the Arctic coast were regarded as an integral part of the empire. Stefansson's Wrangel Island venture had no official support from London. The Soviet Government has formally raised

its flag over the island and in the summer of 1925 settled Chukchi and Eskimo families thereon. A wireless and meteorological station is also to be installed (*Zeitschr. Gesell. für Erdkunde zu Berlin*, 1925, p. 220).

North of the Canadian mainland is the vast Arctic Archipelago claimed by Canada, stretching northward to 83° N. in Cape Columbia. In Mr. Miller's view, while title to all these islands is not legally perfect under international law, it may be said that the right to almost all is not now questioned (Norway has advanced shadowy "discovery rights to Axel Heiberg Island and the Ringnes Islands) and is in a fair way to become complete and admitted. Meanwhile the Canadian government is becoming increasingly solicitous of these far northern lands. Reference to the establishment of official posts and patrols has recently been made in the *Geographical Review* (Vol. 15, 1925, pp. 134–135).

The Canadian claim as officially stated includes all territory west of Davis Strait and longitude 60° W. and east of longitude 141° W. north of the Canadian mainland to the Pole. This raises the question of the unknown lands. Such a claim bears some analogy to the hinterland theory, or more accurately it may be said to rest partly on the notion of territorial propinquity. The basis for the 141° W. meridian rests on provisions of former treaties. The treaty of 1825 between Great Britain and Russia agreed to this line "dans son prolongement jusqu'à la Mer Glaciale," while yet this part of the coast remained unexplored. Again, in 1867, the United States, succeeding to Russian rights in Alaska, confirmed the meridian as boundary "in its prolongation as far as the Frozen Ocean." The treaty of 1867 also defined the western boundary of the Alaskan territory on the given meridian as proceeding "north without limitation, into the same Frozen Ocean."

Such limits suggest a division of the unknown Arctic into three sectors: the Canadian, between 60° W. and 141° W.; the United States, between 141° W. and 169° W.; the Russian, from 169° W. to a meridian between 30° to 40° E. A large area of the unknown would thus fall to the United States. As yet that country has not advanced official claim to any Arctic lands outside her well recognized territory. Her only declaration, in fact, is that renouncing rights in Greenland in the treaty with Denmark over the Virgin Islands.

A New Cod Fishery Off Western Greenland. A new cod fishery of the local and periodic type is described by M. Charles Rabot in *La Nature* (No. 2682, August 29, 1925, pp. 142–143). Twenty-five to thirty miles off the west coast of Greenland in the southern part of Davis Strait is a series of banks, the chief of which, Fylla, is off Godthaab. Cod began to appear here in numbers three years ago where a decade and a half previously a Danish zoölogical expedition had found few. In 1924 Norwegian fishers reaped a rich harvest from these banks. Last season they were joined by fishers of several other maritime nations, and again excellent catches were made. Incidentally it may be noted that the catch must be prepared on board, as territorial waters are forbidden to non-Danish vessels (see note above). A concession, however, has been made for watering the vessels at a harbor convenient to the Fylla bank.

The presence of the fish is evidently closely related to the water temperature. Last summer the cod appeared only at the end of June when the sea temperature rose above freezing point. As regards this condition Davis Strait occupies a critical situation on the border line of the seas recurrently icebound and free and thus recurrently unfavorable and favorable to the fish. The southwestern coast of Spitsbergen lies similarly. Forty-five years ago it enjoyed a flourishing cod fishery, then the fish disappeared; recently they have again been observed in its waters.

The Coal Resources of Svalbard. The classic report on "The Coal Resources of the World" by the International Geological Congress of 1913 treats very briefly of

Spitsbergen. Lack of data and limited development are blamed in the main on the unsettled territorial status of the islands. With Norwegian sovereignty established this disability has been removed, and an earnest of possibilities is given by Dr. Adolf Hoel in "The Coal Deposits and Coal Mining of Svalbard (Spitsbergen and Bear Island)" (*Resultater av de norske statsunderstøttede Spitsbergenekspeditioner*, Vol. 1, No. 6, Oslo, 1925), a report prepared in the first instance for the World Power Conference of 1924.

Up to and including 1924 the total coal export of Svalbard amounted to 1,780,000 tons. In 1924 it was 450,000 tons. Export has been chiefly to Norway, Sweden, and Holland, countries where further market possibilities are considerable. Six mines are now in operation by Norwegian, Swedish, British, Danish, and Russian companies. The Norwegian government has promoted the industry in various ways, and the Swedish government also has subventioned the operation of its nationals.

The Spitsbergen deposits are of Carboniferous, Cretaceous, and Tertiary age. Deposits of all three ages occur in the central coal basin, centered about Ice Fjord. The reserves of this basin (taking into account only seams within 600 meters of the surface) are estimated at 8,000,000 tons thus: the Culm coal at 1500 million tons, the Cretaceous at 1500 million tons, the Tertiary at 5000 million tons. South of Van Mijen Bay is a basin of 6300 square kilometers still largely unexplored but known to contain large reserves of Tertiary coal, probably also of Cretaceous. The Tertiary seams provide an excellent steam coal. The Bear Island coal is of Devonian and Carboniferous age and produces a good coking coal. No definite statement can as yet be made as to the reserves.

Stefansson's Greenland Expedition. Vilhjalmur Stefansson has announced a plan for a series of journeys to Greenland, Baffin Island, Labrador, and Iceland to carry out a broad program of studies, with the main emphasis on Old Norse archeology, Eskimo archeology and Eskimo ethnology. Attention will also be paid to the question of Neolithic culture in Iceland and the Irish discovery and colonization of that island, and their connection with the colonization of Greenland after 982 A.D. On his various journeys, lasting perhaps through a period from three to five years long, Stefansson will associate himself with several of the leading authorities in the world on Irish literature and antiquities, Old Norse literature, Neolithic archeology, Norse archeology, history and language, etc. On one of the journeys it is planned to follow by ship the Old Norse sailing directions according to which they navigated from A. D. 860 to 1410 (and perhaps later) between Norway, Iceland, Greenland and North America (Labrador, Newfoundland). This work will probably be under the direction of William Hovgaard, professor of naval design in the Massachusetts Institute of Technology, who is also a leading authority on the navigation of the Viking Age.

In these plans Stefansson is really returning to the earlier interests of his career as an arctic student and explorer, for his first two scientific publications were an article on grammatical gender in certain relations to Old Norse, published in *American Dialect Notes* for 1903, and on the Icelandic (Old Norse) Colony in Greenland, published in the *American Anthropologist* for April-June, 1906.

Last winter when Rasmussen brought two Greenland Eskimos to New York Stefansson found he could converse with them in certain western Canadian and Alaskan Eskimo dialects of which he has gained a mastery. In addition to a general supervision of the scientific work of the expedition, he plans to use this western knowledge for a comparative linguistic, anthropological, and geographical study of the Greenland, Baffin, and Labrador Eskimos. The scientific results in geography and certain closely related fields will be submitted to the American Geographical Society for publication.

Captain Wilkins' Arctic Expedition. Captain G. H. Wilkins of Australia has announced an expedition to the unexplored region of the Arctic north of Alaska as a preliminary to a longer expedition to the Antarctic in the region between King Edward VII Land and Graham Land. In both expeditions airplanes will be used and ground travel undertaken in case of mishap to the planes. Captain Wilkins lived off the country in the Arctic as a member of Stefansson's party on the Canadian Arctic Expedition of 1913–1918 and is an experienced Arctic explorer and aviator. He has also had two seasons' exploration in the Antarctic, having been with Shackleton on his last expedition. He expects to use Point Barrow as a base and to make his flight in March when the ice is less unstable than at other times. He will provide himself with the means for travel on the ice and for securing food rather than carry emergency rations in the plane. A wireless outfit will be carried so that the members of the party may remain in communication with the base station during the flight. The scientific results of the expedition will be submitted to the American Geographical Society for publication.

WORLD AS A WHOLE AND LARGER PARTS

Some Recent Mountaineering Expeditions and Studies. The Mt. Everest expeditions of 1921 and 1922 have been noted in former numbers of the *Review* (Vol. 11, 1921, pp. 449–450; Vol. 13, 1923, pp. 620–623; Vol. 14, 1924, pp. 324–325). As the route taken by the 1924 party was the same as that of 1922, little new was discovered from the topographical point of view. The entire world knows the tragic story of this expedition—the loss of Mallory and Irvine on the highest part of the mountain; though whether they perished in a vain attempt to reach the summit, or after the goal had been attained, is and will probably remain uncertain. A narrative of the expedition and other data regarding it will be found in the *Geographical Journal* (Vol. 64, 1924, pp. 433–469; see also *Alpine Journal*, Vol. 36, 1924, pp. 195–281. Lieut. Col. E. F. Norton's volume, "The Fight for Everest, 1924, London," 1925, was published too late for consideration here but will be reviewed in a future number of the *Review*).

Probably the most important scientific observations made in 1924 are presented by the medical officer, Major R. W. G. Hingston, in two papers, "Physiological Difficulties in the Ascent of Mount Everest" (*Geogr. Journ.*, Vol. 65, 1925, pp. 4–23; reprinted in *Alpine Journ.*, Vol. 37, 1925, pp. 22–38) and "Animal Life at High Altitudes" (*Geogr. Journ.*, Vol. 65, 1925, pp. 185–198). In the former, the writer explains that "elaborate scientific investigations were impossible, and anything involving complicated apparatus was altogether out of the question." The physiological and psychological observations that could be made were more detailed and reliable than those made on the 1922 expedition. "The most obvious" effect of altitude, writes Hingston, "is the difficulty in breathing" though "when the body was at rest, even at extreme altitudes, the rate of breathing was apparently normal and as comfortable as at sea level." Exertion caused great distress. Somervell, at an altitude of 27,000 feet, "had to take seven, eight, or ten complete respirations for every single step forward." Other effects, varying in intensity and quality with the individual, were accelerated and irregular pulse, lowering of muscular power, loss of the sense of taste, sleeplessness, and mental laziness which, however, "determination can overcome." "A distinct feature in the Mount Everest region is the very pronounced glacier lassitude which develops over tracts of ice" but was "quickly relieved on again reaching rock or moraine." Those who had had previous experience at great heights became acclimatized "very much more rapidly than those entering them for the first time." The benefits of the use of oxygen are still doubtful.

Major Hingston's paper on animal life also brings out new and valuable facts. Choughs were seen at the height of 27,000 feet. Small spiders, "the highest existing animals on the earth," live "in islands of broken rock far above the snow line and 4000 feet above the last vegetable growth."

Since the attacks on Everest have been temporarily abandoned, mountaineering interest in 1925 centered in an expedition organized by the Alpine Club of Canada in coöperation with the American Alpine Club, which succeeded in climbing Mt. Logan, the highest peak in Canada (19,850 feet). Unlike the first Mt. Everest expedition, this one did not break into wholly unknown country. Mt. Logan lies twenty-six miles northeast of Mt. St. Elias, on the slopes of which is the "elbow" of the Alaska-Canada boundary. The country for some distance on both sides of the boundary, including all but the eastern sides of Mt. Logan, was surveyed, though not in detail, by the International Boundary Commission and is shown in their Atlas. Preliminary reconnaissances for the Alpine Clubs' expedition were made in the summer of 1924 and in the late winter and early spring of 1925. The main party left McCarthy, railhead in Alaska, on May 12, and the summit was reached on June 23. The route lay up the Chitina valley and thence over the immense glaciers that reach out northwest of Mts. Logan and St. Elias. Forty-two days were spent on snow and ice, much stormy weather was experienced, and the party suffered severe hardships. On the return, McCarthy was reached July 15. (See Allen Carpe: The Ascent of Mount Logan, *Bull. Geogr. Soc. of Philadelphia*, Vol. 23, 1925, pp. 135–146; *Natural Resources, Canada*, Vol. 4, No. 9, Sept., 1925.)

Aconcagua in the Argentine Andes, the highest mountain in the western hemisphere, was climbed by Messrs. M. F. Ryan, J. Cochrane, F. Clayton, and C. V. R. Macdonald early in February, 1925 (*Geogr. Journ.*, Vol. 66, 1925, pp. 44–46). This was the third fully successful recorded ascent, the first having been made in 1897. The altitude was barometrically determined to be 23,080 feet.

If not the highest, Olympus is unquestionably the most famous peak in Europe. The abode of the Hellenic gods was an object not only of worship but of scientific interest even in antiquity. Xenagoras in the second century before Christ is said to have used geometrical means to find its altitude (about ten stades: possibly about 6,096 feet, though the basis was not sea level and the highest peak probably not the one measured). Until within the last fifteen years, this great mountain massif, with its broad, smooth slopes, its many lofty spurs and deep valleys, and its magnificent forests, was very little known. Standing on the border between Greece and Turkey, its remote caves and glens were a haunt of brigands, who could easily escape pursuit by slipping across the frontier. The acquisition of Macedonia by Greece in 1912 brought the whole mountain under one flag, and since then the region has been more accessible. The highest summit (2917.9 meters, 9573 feet), one of a striking group of alpine crags which overhang profound cirques of glacial origin, was climbed probably for the first time as late as 1913. In 1919–1920 the Geographical Service of the Greek Army surveyed Macedonia and Thessaly and established several trigonometric points on Olympus. Finally, in 1923, the entire upper portion of the mountain mass was thoroughly explored by a Swiss mountaineer and geographer, Marcel Kurz. Kurz made a photogrammetric survey, the results of which are shown on an exquisite map (1:20,000). His book (Le Mont Olympe (Thessalie), Paris and Neuchatel, 1923; extensively reviewed with reduced reproduction of the map in *Geogr. Journ.*, Vol. 63, 1924, pp. 342–346) is a delightful account of his own and earlier explorations, with scholarly chapters on historical cartography and place names.

Three recent publications dealing with Mont Blanc should be mentioned in this connection. The first is Roger Tissot's "Mont Blanc" (Medici Society, London and Boston, 1924), an attractive little descriptive volume, full of charmingly clear photographs reproduced by art gravure; the second, a new edition of Charles Durier's

classic volume, first published in 1877 (Le Mont-Blanc, 8th edit., Paris, 1923). The latter is essentially a history of the topographical and scientific exploration of the mountain, with chapters on famous ascents, routes and cabins, accidents, and observatories. The new edition includes additional notes by Joseph Vallot (he died in April, 1925) and Charles Vallot. For over thirty years Charles Vallot's father, Henri, worked in close coöperation with his cousin, Joseph, in carrying out a careful trigonometrical survey of Mont Blanc and its vicinity to serve as the basis of a map in twenty-two sheets and on the large scale of 1:20,000. The surveys were finally finished in 1921, just before the death of Henri Vallot (1922), and are discussed, with a table of the trigonometric stations and a sketch map of the triangulation net, in a brochure entitled "Réseau trigonométrique du Massif du Mont-Blanc," Paris, 1924. Forthcoming publication of the definitive sheets of the map is here announced.

Finally, no note on recent mountaineering literature would be complete without a reference to Wilhelm Lerner's 727 page history of alpinism, "Die Eroberung der Alpen" (Munich, 1924). This altogether sumptuous volume is richly illustrated with reproductions of early prints and portraits and with mountain views. It is divided into four main parts, covering: the exploration of the Alps from prehistoric times to the close of the eighteenth century; the subsequent history of alpinism in the Eastern Alps; in the Western Alps; and in other parts of the world. A table of first ascents and other tables follow. Though the Caucasus, Himalaya, and New Zealand Alps are amply dealt with in the fourth part, mountaineering in North America is surprisingly neglected. There is a little something on mountaineering in Mexico and on the Duke of the Abruzzi's expedition to Mt. St. Elias, but there seems to be no mention of Mt. McKinley or the Canadian Rockies—not to speak of the mountains of the United States. The book is also marred by invidious comparisons between German alpinists and methods and those of British and Latin countries.

National Parks in Central Europe and the Belgian Congo. The policy of the United States in the establishment of national parks, which began with the Yellowstone in 1872, has been followed in many parts of the globe. A brief but interesting reference in the Annual Report of the Director of the National Park Service (1923) mentions several of these ranging from the ten well established parks of Sweden to the Japanese project for eight parks. Of particular interest is the program now in hand for parks on the international boundary between Poland and Czechoslovakia (Walery Goetel: The Great Program of Poland and Czechoslovakia for National Parks, *Zool. Soc. Bull.*, New York, Vol. 38, 1925, pp. 27–35). The movement here had its inception during the protracted dispute over the Spiš (Jaworzina) region finally settled by protocol of May 6, 1924. Included in the protocol are two agreements, the one having reference to tourist traffic, the other to the foundation of a National Park Reservation "on the analogy of those existing between the United States and Canada." This is the park of the High Tatra (8500 feet), an area of some 400 square miles, in the heart of a region whose alpine beauty draws thither an increasingly great number of tourists, summer and winter. The well established tourist traffic is indeed one of the chief difficulties faced by the park commissioners. The two nations will set up separate administrations, whose plans, however, will be as nearly identical as possible.

Smaller parks are also projected at other points on the long Carpathian boundary. One is in the Beskids on the wooded slopes of the Babia Gora, another in the Pieniny district, Dunajec Basin, northeast of the Tatra, a third at the eastern extremity in the wilderness of Hoverla (6500 feet).

Turning far afield we note also the creation of the Albert National Park in the Belgian Congo. By decree of April 21, 1925, an area of 59,000 acres in the Kivu country was set aside as a plant and animal preserve. It includes the volcano Mikeno (14,540 feet) and the northern slopes of Karisimbi (14,760 feet) and Visoke

(12,200 feet). The southern slopes of Karisimbi and Visoke lie in the mandated territory of Ruanda, and it is expected that a Royal Commission will extend the reserve to cover the three mountains in their entirety. These lofty equatorial volcanoes are vastly interesting to the naturalist, in particular as the habitat of a species of gorilla peculiar to the Kivu country (see Carl Akeley's "In Brightest Africa," 1923). The third article of the decree has special reference to this creature. Provision is made for native rights in regard to pasture, and it is also expected that the reserve will serve as a refuge to the pygmies of the neighborhood (Annex 4, pp. 136–140, in E. LePlae: Les grands animaux de chasse du Congo Belge, *Bull. Agric. du Congo Belge*, Vol. 16, 1925, pp. 3–140).

PHYSICAL GEOGRAPHY

Earthquakes and the Weather. In an article in *Science* of October 2 entitled "Superficial Factors in Earthquakes" Mr. R. W. Sayles gives reasons for believing that the long drought, the low water table, and the low barometer over New England may have been "the straw that broke the camel's back" and precipitated the great Canadian earthquake of the evening of February 28 last. He tells us that the rainfall over New England during the three preceding months was 8 inches below normal with a consequent reduction of pressure amounting to over 38 billion tons, that wells ran dry, and that the barometer was the lowest for two years. Mr. Sayles thinks that as New England has been rising since the Ice Age the defect of pressure indicated may have induced a more rapid uprising and have started the earthquake; but he makes no attempt to estimate its effect.

George Darwin has solved a problem which can be adapted to this case (On the Stresses Caused in the Interior of the Earth by the Weight of Continents and Mountains, *Philosophical Transactions*, Vol. 173, pp. 187–230, and *British Assn. for the Advancement of Sci.*, 1882, p. 106). If we have a series of high and low pressures in long parallel lines, with the pressure between them following the cosine law, his formulae give the maximum shearing stress and its direction throughout the body of the earth. With the areas of high and low pressure elliptical rather than linear the stresses would in general be less.

Let us see what were the pressures over the continent at the time of the Canadian earthquake. At 8 p. m. on February 26, two days before the shock, the low barometer, 28.85 inches, was over eastern Maine; and the high, 30.54 inches, was over the Dakotas. The difference is 1.7 inches. The rainfall can only affect the pressure in so far as the rain remains in the ground, and then the effect is shown by the water table. As wells ran dry we may presume that the water table sank 8 or 10 feet below normal. When we consider the porosity of the soil and the rock, we may take this to be equivalent to the loss of a continuous sheet of water 2 feet thick. To the west there was no snow south of the 43rd parallel, and near the Canadian boundary it was in places 10 inches thick. The snow itself and the water that had gone from it into the earth may be equivalent to one foot of water above normal. So there would be a difference of 3 feet due to water table, and this would be equal to the pressure of 2.65 inches of mercury. The total difference of pressure between high and low would have been equal to 4.35 inches of mercury; and the maximum shearing force developed would have been 28 grms./cm.^{2}. We can compare this with the shearing force that caused the rupture on the San Andreas fault in 1906, which was 133,000 grms./cm.^{2}; or 4750 times as great (see report on the California earthquake of April 18, 1906, Vol. 2, p. 21). If, by analogy with the California earthquake, we assume that the stress that caused the Canadian earthquake was developed in about 100 years and at a uniform rate, we find that the stress due to the meteorological conditions would equal the steady growth of 7½ days. The maximum shearing would

have occurred at a depth of 450 miles; if the earthquake had originated at a depth of 50 miles the maximum stress would have been 1/3 that calculated, or equal to the steady growth of 2½ days.

The meteorological conditions were much less effective at the time of the earthquake than they were two days earlier, and we may not rely on a lag in their action, as we are dealing with elastic phenomena; and there are still further reasons for considering our estimate too high. Without going into more detail we conclude that all that can be said is that meteorological conditions could at most have altered the time of the Canadian earthquake by 2 or 3 days; and we do not know whether they would have advanced or retarded it. The tilt of the terraces of the old glacial lakes suggests that the land to the north is rising more rapidly than that to the south; and if this was the cause of the earthquake, low pressure over New England would have retarded it.

HARRY FIELDING REID

A New Type of Aneroid Barometer. The method of measuring differences of level and absolute height above sea level by means of barometer readings has for many years appealed to reconnaissance surveyors and geologists, because they do not require as a rule great precision in their results and have not the facilities or the time to run accurate lines of level or employ laborious trigonometrical methods.

The principal source of error inherent in the method of determining heights barometrically is that it is impossible to ascertain with any degree of accuracy the mean temperature of the intermediate air between any two stations at which observations are taken. This is not serious if the distance between the two stations is small and the difference of height is less than two or three thousand feet. In such circumstances if barometers are read at both stations nearly simultaneously, differences of level can be obtained of an order of accuracy sufficient for most purposes and which might take days to obtain by other means.

Mercurial barometers are admittedly the most accurate instruments to use on work of this kind, but they are clumsy, easily broken, and difficult to read. In addition it is necessary that corrections be made for change in gravity due to latitude and absolute height and for the actual temperature of the mercury. On the other hand aneroid barometers are light, portable instruments and are easy to read. However, most types of aneroids are likely to get out of order, are not sufficiently sensitive to record intervals of height of less than about 10 feet; and they are subject to lag, that is to say that one has to rest the instrument for several minutes at a station before it will record properly.

With the advent of aerial photographic surveying the importance of obtaining an improved type of aneroid has been strongly felt in all quarters. In the first place it is essential that aviators have some means whereby they may know the height at which they are flying and be able to keep this approximately constant. The aneroid is the only practical instrument devised at present that can be used for this purpose. Secondly, in order to eliminate costly trigonometrical field work or laborious resection methods in the drafting room and in order to utilize the stereoscopical method of drawing contour lines on the photographs it is necessary that numerous "spot" heights be obtained at critical points on the photographs in some way which is cheap and quick.

Through the courtesy of the Navigator Instrument Co. Inc., of San Francisco, the staff of the Society's School of Surveying has had the opportunity of testing and handling a new type of height-recording instrument invented by a Swedish engineer of the name of Paulin and of examining the results of tests made by other unbiased persons with these instruments. The Paulin altimeter is an aneroid constructed on new principles whereby the column of air is virtually weighed by means of the tension in a spiral spring. This tension can be released when the instrument is not in

use and consequently it is much less likely to get out of order than an ordinary aneroid. It is made in several different forms to suit individual requirements; it is light, compact, strongly constructed, and extremely sensitive, being capable of recording differences of level as small as one foot. It should however be pointed out that, sensitive as is the Paulin altimeter, it can never take the place of the precise level. Even under ideal weather conditions there may be an error of 2 feet or possibly more in the difference of height as recorded by this instrument between two consecutive stations. In changeable weather or where the stations are miles apart one must admit the possibility of far larger errors occurring.

Among other advantages of this instrument is its apparent freedom from elastic hysteresis or lag. Obviously this is of prime importance in any airplane flight undertaken for purposes of surveying, because, as has been stated, one of the pilot's most important duties is to fly consistently at a given height above the ground. Again, one has only to imagine the case of a surveyor on the ground using an ordinary aneroid and having to wait several minutes at each point before he can obtain a reading to realize that an aneroid without lag will do the work required in only a fraction of the time. Especially is this so when the groundman's only duties are to determine spot heights of critical points already located and identified on a photograph.

The Determination of Ocean Depths by Acoustical Methods. For over a decade professional hydrographers in every maritime country have fully realized the possibilities in the use of sonic depth-finding apparatus which achieve their purpose by measuring the interval of time taken for a sound to be echoed from the sea bottom. A vast amount of research has been done, and as a result several different instruments have been devised which quickly, automatically, and accurately determine depths by acoustical methods.

Those who read Professor Harvey C. Hayes' paper entitled "The Application of Acoustics to Submarine Surveying" which appeared as a supplement to the *Geographical Review* of October, 1924, will remember that the instrument devised by the U. S. Navy measures the fundamental time interval that determines the depth by making the equal time interval between successive sounds transmitted equal to it. The operator will know when this has occurred, for then the sound of an unreflected signal will synchronize with the echo of a preceding signal. By an ingenious utilization of the "binaural" sense of direction one can determine with this apparatus the direction of the echo and consequently the slope and direction of slope of the sea bed.

The apparatus constructed by the British Admiralty is developed along the same lines as the depth-sounding apparatus patented by Reginald A. Fessenden in this country. By an arrangement of disks revolving at a constant speed a transmitting circuit and a receiving circuit are made so that they are interrupted at exactly equal intervals of time. No sound is heard over the receiving circuit unless the interval in time between the interruption of the two circuits is exactly equal to the time taken for the sound transmitted to be reflected from the sea bed. The British apparatus is perhaps simpler in construction and operation than the American, but it seems probable that the latter is capable of greater accuracy. However, both these instruments depend on an operator actually using his ears to determine the required depth. This is not necessary with the instrument invented by the German physicist Dr. Alexander Behm. By simply pressing three buttons the depth is recorded either on a dial or by ingenious photographic means on paper. The operation of the instrument depends on electromagnetic phenomena and is simple enough. A charge is exploded below the surface of the water at a known depth. The direct sound of the explosion acts on a receiver placed closed to the charge in such a way as to start the instrument in motion. A second receiver, acoustically insulated from the direct sound, is acted upon by the echo, and the motion in the instrument stops.

Obviously the amount of motion in the instrument is in direct ratio to the fundamental time interval. Unfortunately, this instrument is expensive to use owing to an explosion having to take place for every depth sounded.

For the most elegant solution of the problem we must turn to France. Through the researches of Professor Longevin and other eminent French scientists it has been found possible to utilize the piezo-electric properties of quartz so that electric oscillations may be transformed into elastic oscillations. These latter, which are of the nature of sound waves but of a higher frequency, can be just as easily reconverted back into electricity. Thus all the devices used in radio transmission, reception, and amplification are available for measuring the fundamental time interval and consequently the depth. As this time interval is received through the medium of an interrupted electrical current, several very ingenious automatic recording instruments have been constructed, and it is possible by simply pressing a button to read the depth immediately on a dial or for the curve of the bottom of the sea to be traced on paper as the ship proceeds on her course!

An admirable series of articles on this subject appear in *Special Publication No. 4*, 1925, of the International Hydrographic Bureau. It also includes an account of successful experiments made with the Behm sounding machine on the reparation Zeppelin ZR3 during her trial flights over Germany. The object of the experiments was to find out if heights of aircraft when in flight might be determined by acoustical methods.

International Low Water. For most purposes the delineation of the features of the ocean bottom is best accomplished by referring the depths to the plane of mean sea level. But for the purposes of the navigator a low water datum is preferable, and nautical charts without exception make use of some low water plane. The reason for this is twofold: First, a low water plane gives the mariner the minimum depth over shoal areas directly; and second, such a plane makes the corrections for the rise and fall of the tide predominantly positive, whereas with the plane of mean sea level half the corrections are positive and half negative.

Unfortunately, however, various low water datums may be chosen. Without exhausting the list the following may be cited as examples: mean low water, lower low water, spring low water, storm low water, lowest low water. It may therefore happen that two charts of the same area show different depths merely because different datum planes were used; and the confusion is made even worse by the fact that frequently no information is given for coördinating the two datums. In an attempt to eliminate this confusion the International Hydrographic Conference meeting in London in 1919 adopted the following resolution: "It is greatly to be desired that a uniform datum plane should be adopted by all nations, and the following rule is suggested for the further consideration of Hydrographers for a universal datum plane, which should be called 'International low water.' That the plane of reference below mean sea level shall be determined as follows: 'Take ½ the range between mean lower low water and mean higher high water and multiply this ½ range by 1.5.'"

This question of an international datum forms the subject matter of a special publication of the International Hydrographic Bureau (International Low Water, *Special Publication No. 5*, 1925) containing two papers, the first by the Dutch hydrographer, Rear Admiral Phaff, entitled "International Low Water," and the second by Commander H. D. Warburg of the British Admiralty Hydrographic Department, entitled "Coördination of Chart Datums." Rear Admiral Phaff in 65 pages discusses in detail the applicability of the datums of mean low water, mean low water springs, mean low water of solsticial springs, and lowest low tide to the various types of tides. The criterion he employs is the percentage of negative corrections necessary, and he comes to the conclusion that "International low water is an erroneous conception." He recommends separate datums for diurnal, semi-diurnal, and mixed tides, each of these datums to be defined by harmonic constants. Commander

Warburg's paper is limited to six pages. Apparently he does not think as badly of "international low water." He is of the opinion that coördination of chart datums is possible by some such scheme as that proposed in the resolution but suggests average lowest low water instead of lower low water. Apparently, too, he thinks none too well of datums based on harmonic constants, inclining rather to those based directly on observed tides.

H. A. MARMER

OBITUARY

GEORG AUGUST SCHWEINFURTH. The death of Dr. August Schweinfurth in Berlin on September 20, 1925, in his 89th year, marks the passing of the last member of that group of scientists and explorers which included Stanley, Livingstone, and Rohlfs, men who were the pioneers of African exploration during the latter half of the nineteenth century. Schweinfurth's interest in botany early evinced itself, and it was while arranging the Barim and Hartmann botanical collection from the Sudan that he became interested in African flora. On his first trip to Africa in 1863 he explored the region between the Red Sea and Khartoum. He was so successful that he was sent to make extensive explorations in the Sudan between Abyssinia and the Congo under the auspices of the Prussian Academy of Sciences. Schweinfurth spent three years at this task during which time he made an extensive botanical collection, discovered the River Welle, elucidated much of the hydrography of the Bahr-el Ghazal system, and by discovering the pygmy Akka proved the existence of a dwarf race in Africa. For his work on this expedition and its record in his book, "In the Heart of Africa," he was awarded the Founder's Gold Medal of the Royal Geographical Society in 1874.

In 1873 he accompanied Rohlfs on an expedition to the Libyan Desert. Taking up his residence in Cairo from 1875 to 1879, he founded the Société Khediviale de Géographie. Some of his more important contributions appear in the publications of this Society. "Artes Africanae" is another of his better-known books. Schweinfurth's further explorations were confined to North Africa, particularly Egypt.

JOSEPH PARTSCH. By the death of Joseph Partsch at Leipzig on June 22, 1925, in his 74th year, Germany loses one of her foremost geographers. At the time of his death Dr. Partsch was Professor Emeritus of Geography at the University of Leipzig where he had succeeded Ratzel in 1905, after 29 years at the University of Breslau. His earlier work especially was in the field of historical geography, wherein he showed the value of such study for modern problems, as for instance in his papers on climatic change in the Mediterranean region. Many of his holidays were spent in the classical lands of antiquity as fruit of which we have the volume "Physikalische Geographie von Griechenland" (with C. Neumann, 1885) and the monographs supplementary to *Petermanns Mitteilungen*, "Die Insel Korfu," "Die Insel Leukas," "Kephallenia und Ithaka" (Ergänzungsheft 88 (1887), 95 (1889), 98 (1890) respectively). He found another field of interest in Quaternary glaciation, carrying on pioneer investigations in the Mittelgebirge of central Europe: these studies in the Riesengebirge and the Carpathians he continued until shortly before his death. His last work, "Die Hohe Tatra zur Eiszeit," was published in 1923.

Partsch is best known for his regional studies, notably the monograph on Silesia, his home country, "Schlesien" (Vol. 1, 1896, Vol. 2, 1911) and the volume "Central Europe" (1903) in Mackinder's "Regions of the World Series," the longer German version of which, "Mitteleuropa," appeared in 1904. Partsch was one of the members of the American Geographical Society's Transcontinental Excursion in 1912 and contributed the paper "Die Nordpazifische Bahn" to the Memorial Volume.

A detailed obituary notice is given in *Petermanns Mitteilungen*, Vol. 71, 1925, pp. 179–181 while an appreciation of his work appeared in the *Geographischer Anzeiger*, Vol. 22, 1921, pp. 149–154.

GEOGRAPHICAL REVIEWS

The American Frontier

F. L. Paxson. **History of the American Frontier 1763–1893.** xvii and 598 pp.; maps, index. Houghton Mifflin Co., Boston and New York, 1924. $6.00. 9½ x 6½ inches.

"The frontier of the British Empire made its foothold at the river mouths on the Atlantic side of the North American continent at the beginning of the seventeenth century." No statement could combine history and geography more intimately than this opening sentence of Paxson's. No history could be more influenced and determined by geographical factors than that of the American frontier. Here geography may be assumed, implied or expressed, but it cannot be ignored. The author had to tell the story of the march of a line or belt of varying breadth and a thousand miles long, as it swung, bulged, doubled, and looped upon itself across the continent, sweeping through the forested Appalachians, over the dissected uplands beyond, the heavy timber and open plains, the treeless prairies, the steppe, homeless and inhospitable as the sea, growing more arid as it rises, the barrier of snow-capped mountains, canyoned plateaus, and stark deserts, half as wide as the Sahara and exacting more courage and versatility to overcome, to the shores of another sea with few river mouths to furnish a foothold.

This ever shifting belt was made up of people not in hordes like Tatars but in single families, scattered groups, or small companies, every individual of which was either adapting himself to a new natural environment or moving on in search of one. Probably no people in history were ever tried, trained, and rigidly selected for 130 years by a greater variety of position, relief, soil, climate, vegetation or ever went through a more exacting geographical training school. The author must set forth what they did to the land and what the land did to them. He did not undertake to write a historical geography, but he did write a geographical history because he could not help it.

The early colonists ascended the rivers as far as they were navigable, generally to the fall line, and above that spread out, mingling with their riverine neighbors on either side. They penetrated the longitudinal valleys of the Appalachians, along which they were distributed north and south. Settlers from New York, Pennsylvania, Virginia, and North Carolina were for the first time mixed on a generous scale. From the social intercourse and inter-marriage of different strains of British stock, Scotch-Irish, and Germans the American character seems to have been born. The squabbles between the colonies over the conflicting territorial claims of their charters and the spasmodic military raids against the Indians and French may, by their confusion, have helped rather than hindered the movement of pioneers toward the interior. When the general political and military strife ceased they were already at the head of the Mohawk, at the forks of the Ohio, and on the Watauga in east Tennessee. The desperate struggle of the Revolution along the seaboard did not distract them from their quest for new lands, and at its close they were in possession of the Kentucky Blue Grass region and the Nashville basin, while Ohio, Indiana, and Illinois stood empty and open for them to come in.

The American frontier was a region in which civilization was being manufactured out of raw material and personnel. It was based upon the possession of land and the creation of a family home, followed by the group institutions, school, church, crafts, government. The process was repeated by each successive generation, furnishing a social laboratory in which the peculiar spirit and meaning of American life

was wrought out. According to Dr. Paxson the frontier environment involved a rigid selection, in which self-confidence, impatient independence, economic and social equality, distrust of absenteeism and autonomous government were at once the conditions and the consequences of success. Hence in all the states the process of constitution making was influenced by constant pressure from the frontier toward lessening unreasonable restrictions and expanding the share of the people in the direct management of their government. It was this pressure from the frontier which finally broke down the party of the old men who had been leaders in the Revolution and established a democracy named after its first president, Thomas Jefferson. Later it was the frontier which produced William Henry Harrison, Andrew Jackson, and its "bright, consummate flower," Abraham Lincoln, and the momentous changes which followed the career of each.

It was for the sake of the frontier that Louisiana was purchased, but, chiefly from geographical causes, it was half a century before that ample domain was effectually occupied. The Indian tribes were a formidable barrier, but, if the country west of the Mississippi-Missouri had been like that on the east, the Indians would have been soon swept away. The part played by the Mississippi River and its tributaries in the settlement and organization of its basin to the end of its domination by the Civil War has become a commonplace of history and geography.

The influence of the frontier was potent in the War of 1812–1814. The new western states and territories where frontier life still prevailed had been the children and wards of the nation, from which the settler had taken the deed for his land. His high sense of personal honor and dignity was easily sublimated into a sense of national honor. The victories of the war on land were won on the frontier, the defeats were suffered in the old communities of the east. As a result of that war the line of the frontier was pushed from Detroit and the Wabash to Chicago and the Illinois, and there were no barriers left in the roads to the Mississippi.

The mass of frontiersmen were poor and in debt for their land, and the attempts of the Federal government and of state and private banks to collect their claims bred a distrust of financial institutions which remained potent far into the nineteenth century and gave rise to the issues in the campaigns in which another son of the frontier, William Jennings Bryan, became distinguished.

In the years between 1815 and 1850 the United States made its great strides toward nationality. "And at nearly every step," says Dr. Paxson, "the decision was made upon some point presented out of the experience of the region commonly called the West," which was either in the primitive stage of the new frontier or had recently passed beyond it.

By 1841 the frontier had marched to the western boundaries of Arkansas, Missouri, Illinois, and Wisconsin but had changed its character from one of unoccupied or recently settled agricultural land to a boundary between white farmers and red Indians. The transfer of Indian tribes to the area now known as the Great Plains was a clear and direct response to contrasted geographical conditions. The semiarid Plains were then worthless for agriculture but abounded in game, which formed the basis of the red man's economy. The only white inhabitants were a few scattered trappers, hunters, and fur traders; and the colonization of the Indians was, for the time being, a wise and logical solution of a difficult problem.

The lead mines of Dubuque and the pine forests of Minnesota were the physical factors which initiated the settlement of the upper Mississippi basin. The rich cotton lands of the Mexican territory of Texas tempted thousands of southern planters to colonize an alien country, and through them independence for the Lone Star State was speedily won.

The Great Plains and the Rocky Mountains reacted upon the successive waves of western migration somewhat as the fixed blocks of old land have upon the earth waves of folded mountain building. In each case there was a barrier which neither

the human nor the geological waves could cover or sweep away. Across the great barrier the American frontier could not advance unbroken, but it cut a few channels through it. These were the Oregon and Santa Fe trails leading through to the Pacific coast lands where the streams of frontiersmen expanded into pools, essentially similar to the broad spaces from which they came but differing notably in details. This involved a new and more exacting selection. The frontiersman of the Middle West moved on only a few score, or at most a few hundred, miles from his old neighbors; but the Oregon immigrant must possess the means and the courage to undertake and the grit to accomplish a trek of 2000 miles through rugged and hostile country and then to make his home under conditions of isolation hitherto unparalleled. The Santa Fe trail was used only by traders, not by settlers; but it served to dissipate the mythical belief in the Great American Desert and to break up the policy of Indian occupation in the southwest.

The flight of the Mormons to Great Salt Lake and their success in establishing, on the border of the real American desert, the state of Deseret, based on agriculture by irrigation and the peculiar physical features of the Jordan valley which made their success possible, constitute the most remarkable instance in American history of geographic control over human events.

The discovery of gold in California in 1848 started new and flooded streams of migration over and around the great barrier, some overland, some by way of Panama, and some around Cape Horn, composed of a new type of pioneer, not farmers but miners. By 1850 there were three spontaneous colonies beyond the Rocky Mountains, each the fruit of the double distilled spirit of the frontier, owing nothing to presidents or legislatures—Oregon, Deseret, and California.

About 1860 the frontier came under the control of a new factor, the railroad, and its general shift and advance were determined by the position of the railhead on the numerous lines ever pushing westward. The subsequent history of the American frontier consists of a series of local episodes rather than of a general movement. One of these, known as the "Pikes Peak or Bust" of the fifty-niners, following the discovery of gold near the site of the present city of Denver, resulted in the state of Colorado; and a similar discovery in the foothills of the Sierra Nevada brought the state of Nevada into the Union. Arizona and Idaho also owe their political unity to the discovery of mineral wealth.

The former Indian country became the "cow country," full of thrilling adventure and enshrined in romance, which may be regarded as the last form of the American frontier on a large scale. The completion of ten or more transcontinental railroads brought an end to its importance if not to its existence. Its ghost may still be shown upon the map in the form of the eastern and western boundaries of an area of sparse population, which roughly indicates the position of the Great Barrier still unconquered.

Dr. Paxson has told, with erudition and clearness, the story of how the people of the United States took possession of the land. He has not ignored the other side of the story, how the land took possession of the people; but, in his work as a historian, the character and function of the land is necessarily assumed or hidden in a mass of political details. It still remains for the geographer to tell us, not so much what the people have done to the land, but everything ascertainable about what the land has done to the people.

CHARLES REDAWAY DRYER

THE DISMAL SWAMP OF VIRGINIA

C. F. STANSBURY. **The Lake of the Great Dismal.** With a preface by Don Marquis. xv and 238 pp.; map, ills. Albert & Charles Boni, New York, 1925. $4.00. 8½ x 6 inches.

This is an admirable little book, of value both to the scientist and the popular reader. It tells of visits to the miscalled Dismal Swamp at all seasons of the year.

It has long chapters about its animal and plant life and about its geography and geology. Another part, entitled "Human Documents," covers its history. Still another deals with its legend, put into verse by Tom Moore.

About thirty miles long and fifteen wide, the Swamp is half in Virginia and half in North Carolina. It is bisected by a ship canal. In its center is the lonely Lake Drummond. The Swamp is still largely covered by beautiful forest in which roams much big game. Slowly it is being civilized, that is drained and destroyed. And this is a pity, for, as George Washington wrote, "the so-called Dismal Swamp is a glorious paradise." The part of wisdom indeed would be to save for future generations what remains of this "paradise" by taking it for a national forest and game reserve. Would this could be done!

EDWIN SWIFT BALCH

THE VEGETATION OF THE UNITED STATES

O. E. BAKER. **Atlas of American Agriculture.** Part I, The Physical Basis of Agriculture. Section E, Natural Vegetation: Grassland and Desert Shrub, by H. L. Shantz; Forests, by Raphael Zon. 29 pp.; maps, diagrs., ills., bibliogr. Government Printing Office, Washington, 1924. 19 x 13½ inches.

A valuable and beautiful colored map of the natural vegetation regions of the United States, scale 1 : 8,000,000, with 24 atlas-size pages of text, about one-third covered by 56 admirable half-tones of trees, shrubs, and landscapes. The authors state that it is highly generalized and call it preliminary. The reviewer will content himself with description and an expression of appreciation. His annexed diagram sets out the broader divisions in a broad way.

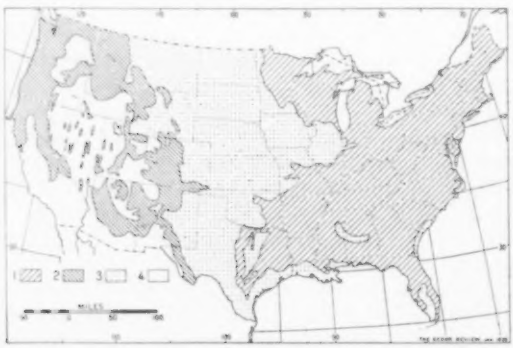


FIG. 1—Diagrammatic map of the vegetation regions of the United States drawn by the reviewer. The regions are: 1, Eastern Forest; 2, Western Forest; 3, Grasslands; 4, Desert Shrubs.

There are three types: grasslands, eastern and western forests, and desert shrubs.

The grasslands (3) cross the country in a north to south belt 500 or 600 miles wide from Mexico to Canada; they are our prairies and high plains, but they also include strips of coast in the Southern States and the Black Belt of Alabama.

"The eastern forest (1) is essentially broad-leaved in composition and of unbroken distribution, covering both valleys and mountains, . . . has 200 species of broad-leaved trees, many of which cover large areas and are of immense value." Of conifers it has but 29 species. Formerly the eastern forests were unbroken and comprised more than 1,000,000 square miles; but now probably not more than 260,000 square miles of merchantable timber is left, half broad-leaved trees and half conifers, of which 20,000 square miles are in the Northeastern States, 20,000 in the Lake States, and 90,000 in the Southern States.

The western forest (2), as the diagram shows, is in two parts, rather massive in the northern part of the Pacific region, continuous along the mountains in the southern part of the Pacific coast, and quite irregular along the Rocky Mountains, with a whole swarm of little linear patches along the crests of basin ranges between. "The western forest . . . is distinctly coniferous in character . . . and

is interrupted by treeless valleys. . . . [It] has only about 100 broad-leaved species, few of which are of any considerable value." It has 65 species of conifers, for which no specific statement is made; but I infer they are of great value. "It now includes 130,000 square miles of merchantable forest, of which about 65,000 square miles lie in the Cascade-Sierra and Coast Ranges in the States of Washington, Oregon, and California, and about the same amount in the Rocky Mountains." "In the British possessions, north of the fiftieth degree of latitude, the two forest divisions come together in one great stretch of continuous subarctic forests, extending from the Atlantic to the Pacific. In the south the forests of the eastern and western regions are also united by a narrow strip of forest peculiar to the plateau of northern Mexico and possessing features common to both regions."

The desert shrub region (4) lies in the valleys and lower parts of the Great Basin, broadening out toward the south, "and along the Mexican boundary forms a continuous strip extending from the Pacific Ocean to the Gulf of Mexico, interrupted only here and there at higher elevations." The character of the desert shrub vegetation is intimated by the names of its three color subdivisions on the map—sagebrush, creosote bush, and greasewood.

The large colored map has nine subdivisions of eastern forests, nine of western forests, seven of grasslands, and three of desert shrubs.

Most of the text is devoted to detailed description of the vegetation, its habitats, and the climatic conditions that control them—a wealth of information wonderfully illustrated with pictures of natural tree and plant groupings. The common names of about 250 plants are given and a list of selected references.

When one takes his narrow, local views from the house windows to the map, he may be disappointed to miss the familiar detail in the generalizations. With the words of "Michigan, my Michigan" in mind, one looks for "Saginaw's tall whispering pines" around Saginaw Bay but finds only beech-maple and oak-hickory groupings. Why that legend of wonderful forests of cork pine of Saginaw, the forests that finally melted away before the ax in 1888? Should they not show somewhere on this map? Surely the fact that they have been cut off has not removed them from a map of natural vegetation. However, generalization is sure to blur detail.

The Department is to be congratulated on the choice of scale, 1 : 8,000,000, for these maps. When folded, 13½ by 18 inches is about the maximum convenient atlas size. The 1 : 7,000,000 relief and geological maps of the United States by the Geological Survey are just too large, except to frame and hang on the wall.

The base map has rivers, relief lightly hachured, names, and a good selection of cities and towns.

The Office of Publications of the Department of Agriculture has a number of copies for free distribution to college and normal school teachers who will make immediate and material use of the work.

MARK JEFFERSON

AMERICAN CLIMATOLOGY

R. DEC. WARD. **The Climates of the United States.** xvi and 518 pp.; maps, diagrs., index. Ginn & Co., Boston, 1925. $4.00. 8½ x 6 inches.

This is a readable book on an interesting theme by a man who knows his subject. Professor Ward is not one to veil his meaning in a cloud of words. He presents his material in an orderly way and with a clearness not always characteristic of academic circles. The book lacks any trace of dogmatism. One hardly realizes that he is reading a textbook: the narrative as well as the matter of the text holds the interest. The secret may be found perhaps in the fact that the book has been slow in maturing. Many articles appearing first in magazine form, published for example in the *Geographical Review*, have here a later setting. The author has had many advantages, not the least being his own training in translating Hann's "Handbuch der Klimatol-

ogie," his work for the "Encyclopaedia Britannica," and a long experience as editor of the *American Meteorological Journal* and as contributing editor of the *Geographical Review*. He has also had access to the Harvard University library; and not far from his desk, in fact under his control, is the extensive material of the Climatological Laboratory of Harvard University whose preparation was originally planned by Professor William M. Davis.

It is pleasant to notice in the Introduction evidence of the friendly relation holding through long years of these two men—two who have done so much for American climatology. "Professor Davis," says Ward, "has been a constant inspiration to me throughout my professional career. I have never failed to receive interested and helpful criticism and encouragement during more than thirty-five years of association and friendship." Truly a fine tribute from the younger to the veteran worker.

There are twenty-three chapters, varying in length from eight to fifty pages, treating of climatic controls, the weather element, frost, winds, rainfall types, cold waves, blizzards, land and sea breezes, climate and health, climate and crops, and finally the climate of Alaska. It is not to be expected that in any of these chapters the last word on the subject has been said; but there are many footnotes and copious references, brought up to the present year.

Without question the book is one that college instructors should use in their courses in geography—if by this we mean the study of man as controlled by environment, for the age is now upon us when the air he lives in rather than the ground he walks on must be given first consideration. When all is said and done, the seat of the phenomena which collectively make climate lies above us in the country of the clouds. This is the *terra incognita* of today; but surveys are preparing, and pathways in the shape of air routes will soon be shown upon our maps. For the present, however, this volume on the "Climates of the United States" serves our needs excellently and gives all that is actually known of surface conditions; that is the flow of the air at the bottom of the atmosphere, and the summed up result, commonly called climate.

Where all is good it is not easy to pick out special chapters as deserving of praise, but we think the chapter on prevailing winds and the following one on mean annual rainfall merit special notice. Contrast, for example, the charts showing prevailing winds in January with those in July. An instructor in geography may very profitably start his class on the trail of the shifting flow from season to season and require his students to link up the regimen of the winds in their own locality with the larger circulation. When the class has mastered the wind controls of their own locality, they will be able to reason why the bottles of heaven, as the clouds are well called in the book of Job, sometimes fail to empty their contents while at other times, when seemingly empty, they quickly fill and suddenly pour forth abundantly. Wind and rain—these are the two great factors in determining the climate of a place.

ALEXANDER MCADIE

THE GOVERNMENT STUDY OF RUBBER PRODUCTION

D. M. FIGART. **The Plantation Rubber Industry in the Middle East.** x and 317 pp.; maps, diagrs., ills., bibliogr., index. *U. S. Dept. of Commerce, Trade Promotion Ser. No. 2*, Washington, 1925. 50 cents. 9 x 6 inches.

The people of the United States with their automobiles approaching twenty millions in number and using about three quarters of the world's rubber are deeply interested in the maintenance of a cheap rubber supply, hence the creation of the Crude Rubber Section of the U. S. Department of Commerce.

Its purpose was "to investigate and report on the possibilities of developing the rubber-plantation industry in the Philippines and Latin America." One of the causes contributory to its formation was the British "Stevenson" Act of 1922 restricting exports of rubber from British possessions after years of overproduction.

The Crude Rubber Section under the direction of Dr. H. N. Whitford is to be congratulated upon the remarkably thorough manner in which it seems to have set about the task. The report under discussion follows the first publication dealing with the "Marketing of Plantation Rubber" and very properly deals with the Middle East, comprising Ceylon, India, Burma, Malaya, Netherlands India, Indo-China, British North Borneo, Sarawak, Brunei, Siam, and the Pacific Islands; for by 1923 these countries were together producing 93 per cent of the total supply of rubber. The report is an exceedingly business-like, illuminating, and well balanced statement, and much of it is of the highest interest to the geographer.

The physical conditions of production are discussed in considerable detail in each of the sections devoted to the separate countries. Of the various elements rainfall has the greatest single importance. The relationship between monthly precipitation and the yield of rubber is brought out in a series of ten graphs. In the main producing countries north of the equator the minimum rainfall is between January and March, and except in Burma the lowest production immediately follows this minimum, this being the "wintering" period when tapping is greatly reduced or stopped while the new leaves are forming. In Java the heaviest "wintering" month is August. Throughout the year the flow of latex increases to its maximum in December in nearly all cases. This rise is almost continuous in Malaya and Sumatra, and rainfall in Malaya is ideal for rubber cultivation. There are neither long droughts nor long wet seasons. Rubber flow is irregular in Ceylon and southern India, while in Burma there is nearly a stoppage in production from July to September. These differences are due to the fact that the excessive rainfall of the summer monsoon is unfavorable to rubber yield. The *Hevea* tree in fact is not really at home in a pronounced monsoon climate with its extremes of precipitation.

Space does not permit of a digest of even the most outstanding relationships between physical features and the distribution of plantations; but it should be mentioned that among those which receive systematic attention in the regional sections are the following: Topographic features (altitude, slope, etc.) as affecting (1) distribution of plantations, (2) methods of regulating run-off and soil wash, (3) relative costs of tapping; nature of the soil as related to the water table, e. g. in the low alluvial soils of Malaya and Sumatra with a high water table rubber seems to grow rapidly during the early years, but the trees soon reach a maximum of yield below that of upland plantations. The maps of the various countries indicate the areas under rubber, and estimates are given of available land suitable for its cultivation. Communication facilities are discussed, railways and ports being shown on the maps. Likewise reference is generally made to the distribution and importance of other crops, and the local food supply always receives careful consideration.

Considering its small size this report gives a very thorough treatment of the human aspects of the plantation, always, of course, in relation to efficiency of labor and cost of producing rubber. We learn a great deal of the constant migration of laborers. Thus the only plantations for which indigenous labor suffices are those of India, Java, and Indo-China; and of these only Java appears to rely to any extent upon near-by residents. These countries together supply only about one-tenth of the rubber of the Middle East. The Tamil population of Madras Presidency provides the rubber labor of Ceylon, where the average annual immigration (1910–1922) numbered 87,000; and in 1921 resident Tamils formed 86.9 per cent of the population of the estates. Burma also draws upon southern India. In British Malaya the average number of Indian laborers arriving yearly (1915–1922) was about 50,000; and in 1921 Indians formed 69.3 per cent of the population of the rubber estates, next in order being the Chinese (18.9 per cent) and the Malayans (10.2 per cent).

Emigration from southern India is greatly influenced by Indian weather conditions, a low monsoon rainfall leading to famine and inducing emigration. But the Madras peasant has a standing encouragement to seek work abroad, where he is better housed,

paid, and fed than he is at home. Similar circumstances affect the movements of Chinese, especially from Kwangtung, Kwansi, and Fukien; but the abnormal economic conditions—of exchange, etc.—existing during and after the war have led to special variation in the number of emigrants. The Chinese go to the rubber estates of Malaya, Sumatra, and Borneo; and the volume and variation of the movement to the former can be partly gauged from the figures relating to arrivals and departures from Singapore between 1911 and 1923, although these presumably represent much more than rubber labor. The lowest number of immigrants (1918) was over 58,000, and the highest (1911) nearly 270,000, while the departures in respective years numbered from about one-third to two-thirds of the arrivals. The dense population of Java furnishes most of the rubber labor in all other parts of Netherlands India and especially in Sumatra as well as a small proportion in Malaya and British North Borneo. Indentured Javanese laborers emigrating to Dutch East Indian possessions varied in number (1914–1921) between 20,248 (1914) and 67,680 (1919). The plantations of Cochin China are mostly worked by labor imported from Tonkin and Annam. Numerous comparisons are made regarding the different races. The general opinion in Malaya seems fairly typical—that the Tamil is not the equal of the Javanese or Chinese. The only objection to the Chinese appears to be the greater fluctuation in his wages. An interesting aspect of labor costs emerges from consideration in the case of each country of the variation of food prices and particularly in respect of rice, this being specially dependent on the monsoon rains.

Statistics of all sorts appear to the reviewer to be handled satisfactorily, and the liberal use of graphs helps the reader greatly to appreciate their significance.

The concluding pages of the book are devoted to estimates of future potential rubber production up to 1930, leaving future plantings out of account, since these would not have come into bearing by that year. Up to 1911 the whole of the plantation rubber from the Middle East came from British possessions. In 1922 the British share was 72 per cent; in 1923 it was 63 per cent, and for 1924 it is here estimated at 53 per cent. The decline in the last two years is of course the result of the restriction policy. In these last years the natives of Netherlands India have become an important and probably a permanent factor in rubber production.

ALAN G. OGILVIE

HISTORICAL AND REGIONAL GEOGRAPHY OF AUSTRALIA

S. H. ROBERTS. **History of Australian Land Settlement (1788–1920).** xx and 427 pp.; maps, diagrs., bibliogr., index. Macmillan & Co. Ltd. and Melbourne Univ. Press, Melbourne, 1924. 10 x 6½ inches.

A. G. PRICE. **The Foundation and Settlement of South Australia 1829–1845: A Study of the Colonization Movement, Based on the Records of the South Australian Government and on Other Authoritative Documents.** xii and 260 pp.; maps, ills., bibliogr., index. F. W. Preece, Adelaide, 1924. 12s. 6d. 9 x 6 inches.

J. S. BATTYE. **Western Australia: A History from Its Discovery to the Inauguration of the Commonwealth.** 480 pp.; map, ills., index. Oxford University Press, American Branch, 1924. 9 x 6 inches.

KURT HASSERT. **Australien und Neuseeland geographisch und wirtschaftlich.** viii and 178 pp.; maps, diagrs., bibliogr., index. (Perthes' Kleine Völker- und Länderkunde zum Gebrauch im praktischen Leben, Vol. 12.) Friedrich Andreas Perthes, Gotha and Stuttgart, 1924. M. 4. 8½ x 5½ inches.

In the three historical volumes listed, each author looks beyond political events to more fundamental economic and social movements, and—particularly Roberts and Price—to the geographical background.

Roberts deals with the extraordinarily complex history of Australian land settlement: complex because of the absence of any uniform federal land policy and be-

cause of many diverse and conflicting elements among the settlers themselves, whether freemen or convicts; farmers, shepherds, cattlemen, or miners; purchasers, grantees, or squatters. The volume is scholarly, well documented, and readable. An abundance of clear, diagrammatic maps in black and white show the advance of settlement province by province. The writer does not become so deeply involved in the legal intricacies of land law and administration (though to these subjects he gives ample attention) as to lose sight of the broader bearings, not to speak of the color and romance, of his theme.

From the compact nucleus of settlement around Sydney we follow the advance of the frontier westward across the Blue Mountains. The discovery of the "well-watered and scantily-timbered Bathurst Plains [in 1813] shattered for ever the conception that beyond the mountains was a desert scorched by winds as devastating as the '*Khamseen* of Egypt,'" as the geographer Malte-Brun had pictured it. Soon after this discovery and with the introduction of "the fine woolled sheep of Spain" came the development of "squatting," that peculiarly Australian form of land occupation, the "unique and unauthorized occupation of large provinces" for grazing purposes. Roberts' story of the spread of the squatters into the wilds, far beyond farms and limits of authorized settlement; the glimpses he gives us of their life and of the adventurous, exploring spirit that led them onward; the dark picture he draws of the insuperable difficulties against which they often had to contend—these are perhaps the finest chapters of the book.

This expansive period of the mid-century was inevitably followed by the fencing-in of the "runs" and by legislation whereby the squatters were enabled, in one way or another, to obtain legal possession of their lands. But accompanying this came speculation in land, the accumulation of vast tracts in the hands of the few, and finally, towards the end of the century, a movement toward governmental repurchase, resubdivision, and closer settlement.

One cannot study the advance of the Australian frontier without being reminded of the advance of our own frontier west of the hundredth meridian: in both cases almost ceaseless have been the conflicts between grazing and agricultural interests: in both, thorny questions have arisen over the disposition of unoccupied tracts; in both, gold discoveries and the influx of miners have added complications to an already complicated situation; above all, in both there has loomed the constant menace of drought.

On the arid plains fringing the desertic regions of the interior, Australia has seen tragic parallels to the premature rush of settlers in the eighties beyond the drought limit in western Kansas, Nebraska, and South Dakota (see the note "Rainfall and Populism in Kansas," etc., in this number of the *Review*). In the volume cited above, Hassert discusses types of grass and herb that grow in the dry parts of Australia. These put forth immense quantities of seeds that lie dormant through the long, dry spells but when the rare rains come spring to life in amazing but short-lived luxuriance. This occasional and treacherous semblance of productivity is characteristic of desert margins and, when understood, leads to no dire consequences. On the other hand, when not understood, it may lure the unsuspecting pioneer into districts that cannot support permanent settlement without irrigation. In 1859, on the northern fringe of the settled part of South Australia, "there had been a succession of good seasons—'there was waving grass on Boolcunda.'" As a consequence the government placed abnormally high valuations on the "runs." Unable to meet the prices, many of the squatters abandoned their holdings; years of drought followed, and, "especially to the north of Mount Remarkable, the saltbush was almost destroyed and 'the fearful appearance of desolation' far surpassed that 'of the deserts of Arabia and Egypt.' In the whole of the north the runs were bleak and useless, more so in the newly occupied bed of Lake Torrens than elsewhere. Within a year 235,000 of 270,000 sheep perished, and the cost of water-carriage went up more than fourfold."

Grenfell Price's study of the foundation and settlement of South Australia is a conscious attempt to "consider closely the geographic and industrial aspects of the story." One important consideration in the selection of the site of the new colony was the proximity of the mouth of the Murray River, seen to be the outlet of a potentially great "inland empire." Another was the fact that the "belt of highlands carries the isohyets far into the interior, and provides a large area of well watered country." These and various other geographical advantages were perceived by the Surveyor General, Colonel William Light, who chose the site of Adelaide (see *Geogr. Rev.*, Vol. 12, 1922, p. 500). In South Australia the adjustment of agricultural practices to environment, particularly to the Mediterranean type of climate, was accomplished but slowly and after many discouragements. For an unduly long time delays in carrying through surveys deprived the people of the use of agricultural land. Overconcentration of population in the city of Adelaide resulted. Grenfell Price shows how these troubles were gradually overcome.

Battye's history of Western Australia likewise reveals to us the difficulties attending the establishment of a new colony where land is superabundant and labor at a premium. In early Australia convict labor was often successfully employed in the preliminary pioneering stage, though when this stage was passed and free immigrants began to come in trouble inevitably arose. Western Australia long tried to hold out against the introduction of convict labor but succumbed finally in 1849.

On the whole, Western Australia was a more or less obscure pastoral colony until the nineties. Then came the gold discoveries and its transformation almost overnight into one of the foremost gold-producing regions of the world. Battye gives an interesting account of the prospectors, their explorations and discoveries; of the rush of population that followed; of the growth of large cities in an unmitigated desert; of the construction of railways and pipe lines; and of the administrative and mechanical readjustments of the entire colony to the new conditions.

Hassert's little regional geography of Australia and New Zealand, like other volumes of the same series, is compact, clear, and balanced. We are led logically from land to vegetation, from vegetation to population, from population to economic life. Important facts are brought out graphically by means of a few carefully chosen statistical tables and simple maps in black and white. It would probably be hard to find a better brief introduction to the Australasian environment and to the outstanding problems in the human geography of Australia and New Zealand.

The Lands About the Mediterranean

M. I. Newbigin. **The Mediterranean Lands: An Introductory Study in Human and Historical Geography.** 222 pp.; maps, index. Alfred A. Knopf, New York, 1924. $2.75. 9 x 6 inches.

This book is intended to serve the needs of those who seek an elementary knowledge of the geography and history of the lands bordering the Mediterranean. The first part contains a sketch of the salient characteristics of the relief, the climate, the vegetation, and the soils of the region and a description of typical modes of cultivation and settlement. The second places each of the great civilizations which has arisen in the basin or in adjacent lands in its geographical setting. In this manner Egyptian, Babylonian, Assyrian, Phoenician, Minoan, Greek, and Roman civilizations, the barbarian and Arabic invasions, the rise of medieval trading communities, and the effects of the Turkish conquests are reviewed rapidly. The text is illustrated by several sketch maps.

The treatment is exceedingly brief. Even as a broad survey the work is not complete. Some civilizations of the area, such as the Slavic, and some districts are omitted or discussed only incidentally. The valley of the Po is neglected on the ground that its climate is not typically Mediterranean. Istria is not mentioned. No at-

tempt is made to present all of the geographic factors that have affected the development of the civilizations considered. The subject is presented, however, in a highly suggestive manner. How the deeds of Mediterranean men have been influenced by many aspects of their natural environment is portrayed so graphically as to arouse the interest of almost any reader. Less advanced students either of the history or of the geography of the region, for whom the book was written primarily, should derive from it a broader conception of the subject and a stimulus to further reading and to speculative thought.

In a work which attempts to confine so vast a subject within such narrow limits a few loose ends are to be expected. Hasty generalizations appear occasionally. Such, for example, is the statement that the stimulus of the "Great Discoveries" combined with "that due to the scattering of Greek scholars after the fall of Constantinople led to the revival of learning" (p. 199). Lack of sufficient qualification leaves some assertions open to doubt. If the comparative isolation of Sardinia and Corsica is ascribed solely to the "areas of old rocks left standing when adjacent blocks sank" (p. 28), as appears to be the case, one is disposed to wonder if all possible causes have been canvassed. The references cited in the "Notes for Further Study" seem to have been selected somewhat at random. More faults of these types occur upon the historical side than upon the geographical. They are not unduly numerous in relation to the mode of treatment, and they are of minor importance. They do not affect seriously the principal conclusions of the author with regard to the effects of geography on man. This is the vital theme of the book. The exposition of it appears to be in the main trustworthy; certainly it is interesting.

W. E. Lunt

Vegetation of the Central "Steppe" of Spain

E. H. del Villar. **Avance geobotánico sobre la pretendida estepa central de España.** Ills. *Iberica*, No. 576, Vol. 12, 1925, pp. 281–283; No. 577, pp. 297–302; No. 579, pp. 328–333; No. 580, pp. 344–350.

The location of the so-called central steppe of Spain is shown on the map accompanying the work of Dr. Eduardo Reyes Prosper entitled "Las estepas de España y su vegetación" published by grant of the Spanish royal family in 1915. This book of 302 pages deals with the various steppes of Spain and the principal plant formations found thereon, but it treats of the vegetation largely from the floristic standpoint. Earlier Willkomm in 1896 published his "Grundzüge der Pflanzenverbreitung auf der iberischen Halbinsel" as the first volume of "Die Vegetation der Erde." This work leaves much to be desired from the dynamic point of view as emphasized in recent ecologic publications. Dr. Emilio del Villar, imbued with modern methods, attempts to fill the deficiencies of his predecessors in his "Introducción a la fitogeografía sinecológica de la Peninsula Ibérica," finished in 1921. Owing to difficulty in finding a publisher it has remained in manuscript, and the résumé which has appeared in *Iberica* deals solely with the vegetation of the central steppe of Spain instead of the entire peninsula.

The author first presents his problem and his method of attack. He explains his terminology, which follows that of Dr. Clements of the American school of phytogeographers ("Plant Succession," 1916), and enumerates the elements of the vegetation of his region, the country between Guadalajara and Madrid in the north and Ciudad Real and Albacete in the south. The second part opens with a brief reference to the climatic conditions. Tables of monthly temperature, rainfall, and evaporation for Madrid are given as typical. The rainfall is 425 millimeters, evaporation 1604 millimeters. "To such conditions corresponds a vegetation eminently xerophytic, woody and more or less schlerophyllous, but not deprived of trees." There follows a description of the climax vegetation, xero-quercetum, with the holm oak

(*Quercus ilex*) as the dominant tree, the oak (*Quercus faginea*) being a rival in certain areas. Today only scattered remnants of the woodland cover remain; fires, goats, sheep, man, and other agencies are responsible for the destruction. Desertization is still in progress and can be registered photographically. In Part III Dr. del Villar describes the so-called steppe which succeeds. In the subserial stages represented, shrubs and herbs figure largely. For example there is the *espartal* with *Macrochloa tenacissima* dominant and the *tomillar* with *Thymus zygis*.

The fourth and last installment of the paper deals with the anteclimatic stages and priseries—the plants of the rocks, the gypsiferous and saline tracts, and the humid areas of the river valleys which cut the undulating surface of the xerophytic country; the post-climax of the *vega*, or country which lends itself best to cultivation, and finally the transition types which are subjected to constant shifts of conditions.

The illustrations are especially helpful, as with their long descriptions and reference to plant species they emphasize the points described at length in the text. The work itself indicates the richness of the field for research along modern ecologic-phytogeographic lines presented by the Spanish flora, and it is to be hoped that Dr. del Villar will receive the encouragement in his investigations that his ability should command.

JOHN W. HARSHBERGER

OFFICIAL CARTOGRAPHY IN THE SCANDINAVIAN PENINSULA

Sveriges kartläggning. En översikt. viii and 318 pp.; maps, bibliogr. Kartografiska sällskapet, Generalstabens Litogr. Anstalts, Stockholm, 1922. 15 kr. 10 x 7 inches.

Norges geografiske opmålings virksomhet gjennem 150 år. 52 pp. (in French, pp. 45–52); maps, ills. Norges Geografiske Opmåling, Grøndahl & Sons, Christiania, 1923. 9½ x 6 inches.

The official maps of Sweden are produced by several organizations whose combined activities permit the presentation of a graphic picture of the country's physical characteristics and cultural development. Official mapping had its inception with the Land Survey as early as 1628. The land survey maps, ranging in scale from 1:100 to 1:100,000, are as a rule on the large side, mostly 1:4000, except in Norrland where 1:8000 is generally used. These maps are not published; but three copies are drawn up, for the title holder, the county seat, and the Federal Land Survey Office in Stockholm respectively. As these maps date back from various periods, some of them very early, they offer important material for research in historical geography and particularly in regard to human occupation and utilization of the land.

The cadastral maps cannot, however, be readily combined into larger units. To obtain a good base map it is necessary to adjust them with the aid of the state triangulation surveys. This has been done, and Sweden is thus provided with a large-scale base map on which detail has been very carefully worked out. It furnishes a base for the economic map and for the topographic map and its derivatives, the synoptic and hypsometric maps.

The topographical mapping of Sweden has now been completed, the work having taken over a hundred years. The field survey began in 1810; the first sheet was engraved in 1826, the last in 1924. The map sheets for southern Sweden are drawn on a rectangular net and on a scale of 1:100,000. For northern Sweden they are on a meridian projection net and scale of 1:200,000, though the more densely populated and highly cultivated lands of the Norrland littoral are also available on the scale 1:100,000. Various scales have been used for the field work, but most are now on the scale 1:50,000. Some of these "sketch sheets" have been reproduced by pho-

totypy on the same large scale. Some years ago the work of revision and resurveying was begun. Although used only for military purposes up to 1857 the ordnance map has now become indispensable for civil usages.

Based on the topographic map is the general, or synoptical, map in 25 sheets on the scale 1:400,000. It shows the main features of the natural and man-made landscape. Designed primarily for military requirements, it also serves many civil needs and has been overprinted to show motor roads and power lines and has been adopted as the Swedish air line map. The hypsometric map is issued in 17 sheets on the scale of 1:500,000, relief being shown by altitude tints.

The economic map shows occupation and use of the land with a great wealth of symbols. The scale is generally 1:50,000 or 1:20,000, at present only the latter being used. Excepting the unpublished land survey maps, it is the best available for a study of the agricultural uses of the land. As yet, however, it covers only the cultivated lowlands of the densely populated areas of southern and central Sweden.

The first sheets of the geological map were published as early as 1862, and the mapping has been practically completed for Götaland and Svealand. The most generally used scale is 1:50,000; but 1:100,000 is used in Bohuslän and eastern Småland, and 1:200,000 in the south Swedish highlands. The peat investigation maps are also worthy of note. They cover south and central Sweden and are printed on the topographic map as a base. In addition a card catalog has been compiled giving detailed information of each peat bog.

Hydrographic survey began in 1756, and the oldest of the hydrographic charts in use dates from 1861. The scale of the charts ranges from 1:15,000 (Göteborg harbor) to 1:100,000 (Baltic Sea and North Sea). Besides these are a number of official maps of specific distributions, such as forestal, agricultural, water power and mineral resources, climate, and hydrography of the lands.

Finally something should be said of Sweden's share in the International Millionth Map of the World (detailed accounts are given by A. H. Byström in *Ymer*, 1910 and 1914). Sweden is concerned in 9 sheets, of which 3 lie principally in Norway, 1 in Finland, and 1 in Germany. Of the remaining four maps three are already finished.

In Norway, map surveying was not commenced until 1773, and less of that country has been surveyed than of Sweden. On the other hand coöperation between the various mapping agencies is better, the work being concentrated in the Geographical Service, whereas in Sweden greater independence does not always lead to satisfactory results.

The topographical maps are generally on the scale 1:100,000, the same as the corresponding Swedish maps. For the rectangular net used at first the polyhedral has been substituted. The present program calls for completion of the topographical mapping not later than 1958.

Departmental maps on the scale 1:200,000 were the first official maps for Norway and the principal maps until issue of the topographic sheets was commenced. For large areas in southern Norway they are still the best available maps. Publication of the general map of southern Norway on the scale 1:400,000 began in 1868 and was completed in 1910. It will not be carried out for the northern section, its place and that of the departmental maps having been taken by the new general map of Norway, scale 1:250,000. This map is printed in 9 colors and uses relief shading. Up to 1923 9 sheets had appeared.

Military maps are not published, but field maps for military use are available. The whole of the Norwegian coast is surveyed hydrographically, the general scale being 1:50,000. During the past 15 years photogrammatic surveying has been carried out, since 1920 using the Zeiss stereo-autograph. This method has been used privately in Sweden but not in the national work, chiefly because more of the landscape is forest-covered. In 1922 Norway began work on the International Millionth Map, in 7 sheets of which she has participation.

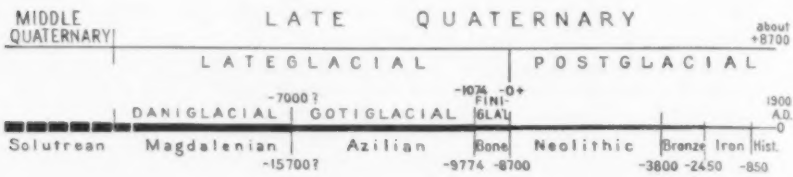
In sum it may be said that, in spite of the large and relatively rough forest-covered terrain, the short summers, and the limited funds available, the mapping of the Scandinavian Peninsula, and especially Sweden, is as good as or better than in any corresponding section of the world, absolutely as well as relatively.

OLOF JONASSON

QUATERNARY TIME STUDIES

GERARD DE GEER. **Förhistoriska tidsbestämningar (Prehistoric Time Scales).** *Ymer*, Vol. 45, 1925, pp. 1–34.

In the figure reproduced herewith De Geer gives his and Ragnar Lidén's late-Quaternary geochronology in its present state of development and his correlation of the cultural chronology of northern Europe. Chronology based upon varved clays extends about 13,500 years back from our time, that is back to the uncovering from the last ice sheet of central Scania and the Baltic north of the island of Bornholm. It reaches back about to the beginning of rapid retreat of the ice edge after this had halted and oscillated for a long time. The existence of a Baltic ice lobe covering northern Germany and most of the Danish Islands, as indicated on De Geer's map, Plate 2, does not seem probable after the studies on the ice retreat by V. Milthers, Henrik Munthe, and others (see E. Antevs: The Retreat of the Last Ice Sheet in



Eastern Canada, *Geol. Survey of Canada Memoir 146*). According to these latter researches the uncovering of Zealand and of northern Germany, estimated by De Geer to have taken some 2000 years, appears rather to represent several times that length. Thus it seems appropriate to the reviewer to count gotiglacial time from the beginning of rapid retreat when the ice front stood on the northwest-southeast diagonal of Scania and north of Bornholm. De Geer now includes the Fenno-Scandian moraines in the gotiglacial instead of the finiglacial.

Starting from the idea that in easily reworked material, like glacial gravels, beaches ought to have been formed in *exposed* situations during single storms of exceptional violence, De Geer also has made an attempt to reconstruct *contemporaneous* postglacial shore lines in Sweden formed as the land rose to its present position and to use these for dating of human culture. In the region of Stockholm a shore line developed in all points of the compass was found at about 60 meters above the sea; and this level is on good grounds believed to represent the limit of transgression due to sinking of the land in postglacial time. With the help of one-sidedly developed beaches this limit of submergence—already known in southern Sweden—has been determined in the central parts of the country. A map, Plate 3, shows the contemporaneous isobases, the isochronobases, of the transgression.

The next step was to determine the age of the transgression. This has been done by the relative position of the transgressional limit between the present sea level and the highest Baltic limit and by Ragnar Lidén's survey of the uplift of Ångermanland (63° N.) and the length of the postglacial time (see *Geogr. Rev.*, Vol. 15, 1925, p. 282). Near Bollnäs (61½° N.) the postglacial limit lies at an altitude of 192 meters, or at 79 per cent of the highest Baltic limit at about 242 m. If the contemporaneous limit in Ångermanland is supposed to lie at 79 per cent of the Baltic limit at about 250

m. in that region its altitude will be 200 m. This level, however, was passed by the receding shore line about 200 years after the bisection of the ice remnant near Ragunda, the zero year, or about 8500 years before our time.

The transgression age known, the remains of human culture directly associated with the coast line can be dated. Thus, if a find occurs at 41 per cent of the postglacial transgressional limit its corresponding level in Ångermanland is 82 m. above the sea, which level was passed by the receding shore line 3300 years after the bisection, or about 5400 years before the year 1900 A. D.

De Geer's results upset many prevailing ideas about the late-Quaternary history of Scandinavia, especially as regards changes of level; and geologists and archeologists alike will look forward with keen interest to the publication of the data and of the detailed discussion of the problems.

ERNST ANTEVS

Quaternary Climates. J. Claude Jones, "Geologic History of Lake Lahontan; Ernst Antevs, "On the Pleistocene History of the Great Basin"; Ernst Antevs, "The Big Tree as a Climatic Measure"; Ellsworth Huntington, "Tree Growth and Climatic Interpretations." v and 212 pp.; maps, diagrs., ills., index. *Carnegie Instn. Publ. No. 352*, Washington, 1925. 10 x 7 inches.

A healthy spirit is indicated in this volume in that the three authors of the constituent papers claim different results based upon the same or similar data, and they are all published by the same institution. The study is based upon the facts disclosed in the Great Basin of Nevada and portions of adjacent states. In that region there were at least sixty Pleistocene lakes, and these lay in the most favorably endowed of the one hundred and twenty-five basins without surface outlets that distinguish the region. The lakes are climatic registers, and their astonishing character and significance are more and more clearly brought to light with continued study of their phenomena. For example, Jones concludes that to support Lake Lahontan in the western part of the basin at its high-water mark it would be necessary to increase the run-off 30 per cent, decrease the evaporation to 45 inches, and more than double the rainfall. Antevs sees difficulty in conceiving so great an increase of moisture brought over the mountains into the basin; and in his view this difficulty is enhanced by the fact that the relatively insignificant glaciers in the mountains speak decidedly against heavy rainfall. On the other hand, Huntington makes a good deal of the very snowy winter of 1906–1907 in the High Alps where Maurer found very little snow over 3000 meters, whereas at lower levels there was much more than the usual amount. In addition, Huntington extends the meaning of this illustration to affect the whole question of origin of the glacial period, believing that the earlier geological view of reduced temperature as the initial modifying cause should be challenged and that greater weight should be attached to increased storminess with attendant greater precipitation and the self-stimulating effect that would follow in maintaining a snow-and-ice cover once it was formed. The startling conclusion is reached by Jones that Lake Lahontan had its beginning between 2000 and 4000 years ago and reached its maximum depth and extent about 1000 years ago. Antevs takes issue with him on this point and believes that the basis of Jones's argument can be challenged step by step whether it relates to former glaciers, post-lake dissection of deltas and bars, the chemical effects upon lake water of outlets and changes in outlets, disintegration of the tufa deposits in postglacial time, and so on. A challenging paper is Antevs' "The Big Tree as a Climatic Measure." Though agreeing with Huntington in many respects he believes that no satisfactory interpretation of the Sequoia curves can be made in relation to the climate of the past until we have more data on the relation between precipitation and the growth of the big trees in dry situations and a better knowledge of the rôle played in the growth of the tree by the radiation

of the sun. He is hopeful, however, as to the possibilities of such a study. Most interesting is his suggestion that the Sequoia curve may eventually afford a possibility of bridging the gap between the Swedish postglacial geochronology and historic time. In unpublished studies by Lidén on clays in fiords of the Gulf of Bothnia there may be a basis for correlation with the curves of growth of the big trees.

The most important of the scientific values in this memoir relates to future study. The earlier pioneer work of King, Russell, and others had given us wide and suggestive interpretations based upon extraordinarily able field work. The present study lifts the whole investigation to a much higher scientific plane; and with the help of other sciences—biology, chemistry, and meteorology in particular—new considerations have been brought into the problem, among which the study of the rings of growth as initiated by Douglass, the studies of tufas by Jones, and the closer analysis of climatic curves by Antevs are among the most significant.

ERNST ANTEVS. **Retreat of the Last Ice-Sheet in Eastern Canada.** iii and 142 pp.; maps, diagrs., ills., bibliogr. *Geol. Survey of Canada Memoir 146: Geol. Ser. No. 126*, Ottawa, 1925. 25 cents. 10 x 6½ inches.

Dr. Antevs, by a study of varved clays (i. e. seasonally banded fresh-water clays deposited in glacial marginal lakes) has brought new light and fresh enthusiasm to a study of glacial history in northeastern North America. With prodigious energy he has plunged into an investigation characterized by wide horizons no less than by close analysis. He is seeking to establish an exact postglacial chronology along the lines of an earlier study published by this Society (The Recession of the Last Ice Sheet in New England, *Amer. Geogr. Soc. Research Series No. 11*, 1922). His field investigations in 1923 for the Canadian Geological Survey are now published in similar form with varve curves, photographs, diagrams, maps, and a still more intense application of analytical methods.

In the Canadian memoir Antevs discusses the different modes by which the varved condition in sedimentary deposits is brought about, the conditions controlling ice recession, the rate of recession (over 400 feet a year in the Timiskaming basin in northern Ontario), the relationship between the glacial history of North America and Europe, and the probable bases of correlation across the Atlantic. His continued study of these and related questions is guaranteed by a two-year grant from the Shaler Memorial Fund of Harvard University, and further publications will be eagerly awaited by all scientists interested in this far-reaching question.

EASTER ISLAND AND ITS MYSTERIES

J. MACMILLAN BROWN. **The Riddle of the Pacific.** xii and 312 pp.; maps, ills., index. T. Fisher Unwin Ltd., London, 1925. 10 x 7 inches.

Easter Island, the so-called mystery island of the Pacific, has fired the imagination of yet another investigator, Professor J. Macmillan Brown, Chancellor of the University of New Zealand. Dr. Brown's book reviews all of the evidence hitherto published upon Easter Island and presents certain new evidence gathered during a five months' residence upon the island.

"The Riddle of the Pacific" is a product in which are blended recorded facts, native myths and legends, and the author's theories as to sunken island empires. It is this blending of fact and myth, with the author's fancy serving as leaven for the whole mass, that makes the book particularly enjoyable reading; but this same blending renders it a book to be used with caution by the serious student. The author's habit of frequently presenting the products of his imagination as unqualified facts is the stumbling block to the student who seeks only the authentic facts about Easter Island history and culture.

At the outset the author develops the theory that the Easter Island monumental platforms and statues date from a time when archipelagoes, no longer existing, reared their heads above the ocean to the east and to the west of Easter Island. The reports of early European navigators as to land seen but not found again by later explorers are the principal historical basis upon which Professor Brown erects his superstructure of a hypothetical island empire. Sala-y-Gomez, lying some three hundred miles to the east of Easter Island, is regarded as the remains of a former extensive archipelago. To the west there is assumed to have been another now sunken archipelago, and from it, after its submergence, is supposed to have come Hotu Matua, the legendary first king and bringer of cultivated plants and domesticated animals to Easter Island. At the time of Hotu Matua's arrival Easter Island is imagined as peopled by tens of thousands of slaves, whose business it had been to erect platforms and to carve and erect statues for their imperial masters of the surrounding archipelagoes. The island in fact served as a vast cemetery. The author does more for Hotu Matua than the native legends, for he makes of him a real culture hero and fills from his imagination the gaps left in the native stories. Whether or not geographers take issue with Professor Brown as to his hypothetical sunken archipelagoes, I am sure that most anthropologists will not agree with him as to the probable manner in which Easter Island culture developed. With extreme naïveté he attributes to Hotu Matua the direct establishment of practically everything in Easter Island culture and notably the features of social and religious culture. He makes no allowance for the gradual development and crystallization of social organization and religious ceremonial nor for the factor of diffusion. It is this attitude of the author that everything was "cut and dried" by Hotu Matua with which most anthropologists will disagree. Certain other naïve assumptions appear here and there, as, for example, the idea that environment determines culture and that petroglyphs of animals and plants necessarily indicate totemism.

Professor Brown has ideas, not generally held by students of American anthropology, as to the cultural debt that South America owes Polynesia. In his own words they are as follows: "Whether it was from the Marquesas or not that the influence of Polynesian great-stone work was directed towards the South American coast, the likeness of the cyclopean structures of the two areas is sufficiently apparent. Every feature of Polynesian great-stone work is repeated in the great-stone work of the Andes; and the impetus did not come from America, if we are to judge by the absence of all American products and arts in the Pacific; it must be the other way, as we find purely Polynesian products and methods on the coast of America and evidences that Polynesian warriors swooped down upon the wealthy cities that were approachable by sea. The most probable history is that since ever the fatherland, Hawaiki, began to be too narrow for its population, expeditions went off in search of new lands; most went west; but some must have made for the east by getting south into the latitude of the westerlies. And these may have taken the taste for cyclopean stonework and the art of it; and from the coast their influence went up with the people of the coastal empires to the high valleys and plateaus of the Andes. They certainly took with them the art of carving the human figure and especially the human bust in stone; these appear not merely in Tiahuanaco but in the stone images of the Valley of Huaraz in central Peru. But it is in the great ruin to the south of Lake Titicaca that their influence especially appears; for they naturally, as voyagers, clung to the shores of an inland sea when they left the coast" (pp. 269–270).

In spite of the above strictures, the volume on Easter Island is to be regarded as a distinct contribution to the subject. The author is to be commended for his fearlessness in setting forth the hypotheses which he regards as best explaining the facts concerning Easter Island, facts which hitherto have not satisfactorily yielded to interpretation. In solving a problem as knotty as that of the history of the Easter Islanders, hypotheses such as those Professor Brown advances do at least serve the

purpose of stimulating further efforts. The value of his book lies not only in the full discussion of Easter Island culture and its comparison with the culture of other Polynesian islands but also in the series of excellent illustrations.

E. W. GIFFORD

A NEW MAGAZINE OF VOLCANOLOGY

Bulletin Volcanologique, Organe de la Section de Volcanologie de l'Union Géodésique et Géophysique Internationale, Nos. 1 and 2, 1924, 3 and 4, 1925, Naples.

Several sections of the International Union are publishing bulletins. Four numbers of the *Bulletin* of the Volcanological Section have so far appeared. The *Bulletin* proposes to publish: (1) official acts of volcanological sections, national and international; (2) a bibliography of contemporary papers on volcanoes; (3) notices concerning the normal activities of the principal volcanoes; (4) short accounts of paroxysmal phenomena; (5) notices of submarine volcanoes; (6) notes and short memoirs on volcanology and related sciences.

This program is well carried out in the numbers under review. They include the proceedings of the Volcanological Section at Rome in 1922 and accounts of the volcanoes of Japan, of the Canaries, and especially of those of Italy. There is an interesting description of the Isle of Cinders, a submarine volcano which appeared off the coast of Annam in March, 1923; a rather long memoir on the recovery of potash, alumina, and silica from the ejecta of Italian volcanoes; an account of the series of eruptions of the volcano of Réunion (with a bibliography); and reviews of many volcanological papers. The various articles are printed in English, French, Italian, or Spanish, according to the nationality or predilection of the writer.

The Section of Volcanology and especially its secretary, Professor Malladra, are to be congratulated on the excellence of the *Bulletin*.

HARRY FIELDING REID

A CHRONICLER AND MAKER OF BRITISH HISTORY

FOSTER WATSON. **Richard Hakluyt.** ix and 99 pp.; ill. (Empire Builders.) The Sheldon Press, London; the Macmillan Co., New York and Toronto, 1924. 2s. 6d. 7½ x 5 inches.

It says much for a man's work that after an interval of 230 years it should inspire the creation of an organization to continue his aims. The Hakluyt Society was founded in 1846; on the occasion of its jubilee Sir Clements Markham spoke briefly on its inspirer's life and achievements. Other similar accounts have appeared, but it is remarkable that no considerable biography of this great English geographer should have appeared till now. Professor Watson conveys with much feeling the spirit of Hakluyt's work and illuminates it by relation with the geographical movement of the times, both practical and academic. Hakluyt's influence, however, was immediate as well as remote, a direct stimulus to the colonial and maritime enterprise of the day. Of special interest is the chapter dealing with Hakluyt as a pioneer of British colonization, a phase of his life that has been more or less overlooked. Hakluyt was one of "that remarkable group of men who petitioned James I for patent for the colonisation of Virginia." Before he wrote the work by which his name lives he was preoccupied with the ultimate problem of the discoveries. "To what use could all the sea-adventures be eventually put?" The first edition of his "Principall Navigations" appeared in 1589, but the "Discourse Concerning Western Planting" was written in 1584. This work, which is still little known, remained in manuscript until 1877 when it was published for the first time, the credit for this praiseworthy undertaking going to the Maine Historical Society. "The essential merit of Hakluyt's view of colonisation is that it is based

upon mutual services and benefits between the colonising country and the colonies, and, indeed, wherever practicable, between the colonists and the natives. The *Discourse* is a contribution not only to English social history but to the history of human progress."

Geography as a Science

Camille Vallaux. **Les sciences géographiques.** viii and 413 pp. Librairie Félix Alcan, Paris, 1925. 25 fr. 9 x 5½ inches.

Vallaux limits his definition of geography to a science of things and not of men and consigns mankind to the place of one of the lesser factors of earth forces. He parcels out most of the hobbies and specialties of the American geographers to other branches of learning. The Social Science group in this country would find much to enjoy and applaud in his book. He does not, however, utterly deny our geography. He recognizes the duality of the science under the terms physical and human geography; the former of fine orderliness, and the latter an anarchical chaos. In chapter after chapter he seeks without success to find some way of uniting them, until finally one is convinced that his trials are not so much in the hope of finding some agreement as in the desire to show their divergence and utter incompatibility.

The treatise is divided into two parts: geography as an autonomous science, and geography as an auxiliary science. However hard he hits, unconsciously perhaps, the American geographer in his vigorous defense of physical geography, there will inevitably arise from a serious reading of the book some clearing up of the hazy borderland between geography and the other closely allied subjects for which now we are apt to rely on Fenneman's exposition of regional geography and his diagram of contacts. Vallaux does not believe that the regional definition is adequate for the use of either physical or human geography.

He aims his shafts at the numerous presentations under the name of geography, as for instance, the theory of economic destruction so extensively treated by Brunhes (Human Geography, pp. 330 *et seq.*). The assumption of this theory by geographers Vallaux likens to an adornment of tinsel; but he does not blame geography alone for it since the theory, he says, is a heritage of the abstract and formal science of political economy.

Altogether the discussion is presented with a thoroughness and vigor that is admirable. And even if the reader does not care to accept the conclusions, he must at least feel that the author writing from the standpoint of a believer and almost a worshiper of physiography has done himself justice. Robert M. Brown

Geography for Teachers

Mark Jefferson. **Principles of Geography.** v and 135 pp.; maps, diagrs., ills., index. Harcourt, Brace & Co., Inc., New York, 1926. $2.50. 10½ x 7½ inches.

"The power of the understanding is very great, that of the misunderstanding knows no limit." With this sentence of Borden Parker Bowne, Professor Jefferson opens his "Principles of Geography," and in the spirit of the quotation the text has been written. The book is a challenge to misunderstanding, particularly misunderstanding arising through the acceptance by teachers and students of whatever may be taught without any critical examination in the light of common sense and common experience. It is a challenge to the persistence of error and of the geographical myths that have appeared in our texts through so many generations. It is a text calculated to stimulate in the minds of teachers and students a healthy skepticism. And since it is a text for teachers of teachers, it should have a decided influence on the quality and accuracy of geographical instruction.

Professor Jefferson presents and discredits a number of statements regarding the earth and man's activities still current in geographical teaching, particularly the myths descriptive of the lands of the high and low latitudes and of their inhabitants. His own statements of geographical principles are carefully reasoned. Wherever possible their truth is demonstrated by a map or chart exercise or by an experiment to be performed by the teacher before the class. The author has endeavored to bring to geography the experimental exactness of physics or chemistry.

It is with reference to these same map exercises and experiments that a vague doubt arises in the mind of the reviewer. In his eagerness to dispel misunderstanding has not Professor Jefferson perhaps overestimated the "power of the understanding" of the users of his text? The exercises that illustrate the construction of different map projections are difficult, and it is questionable whether they are a necessary part of the training of a geographer. Some of the experiments are anything but simple and demonstrate laws that should have been established by the students in the physics laboratory. It is to be presumed, however, that the exercises have been carefully tested and their practicability proved, since this is not a new book but a public printing of the "Teacher's Geography" that has gone through so many private printings for use in the author's classes in Michigan State Normal College.

After a brief chapter on maps, which should better have been incorporated in some of the later chapters, there is a discussion of "Where the People Are" followed by a chapter on "Why the People Are There." It is a method of treatment decidedly unusual in these days of regional geography; but it is a method, nevertheless, that may be thoroughly geographic. It provides the opportunity for setting sharply the limits of the field of geography. In view of the author's studies of population it should be a particularly satisfactory method, but unfortunately it is obscured in the later chapters. Professor Jefferson has very properly discarded the orthodox method of presentation, sometimes called the systematic method, with its explanation of topography and climate followed by a discussion of their effect upon man, but in its place he has substituted a reverse order that still leaves something to be desired. After the earlier chapters on population distribution, man is pushed into the background; and the reader finds himself in an exposition of rainfall and temperatures and winds that appears to have as its prime purpose an understanding of the phenomena themselves rather than an understanding of their influences in the relationships that man has established to his environment. The many experiments here serve to exaggerate the importance of the physical phenomena. Too much emphasis to the exclusion of their human significance makes of these physical facts principles of climatology or meteorology, not principles of geography.

It is not suggested that the explanation of the phenomena of climate should be omitted, but there should be less emphasis upon the physical facts and more emphasis upon their influences on man. Cause and effect are too widely separated. They should be more closely interlocked. It is to be regretted that Professor Jefferson does not follow his chapter on the distribution of population with other chapters explaining that distribution in terms of rainfall, temperature, soils, and accessibility. The absence of any discussion of topography and its influences would indicate that that subject is to be treated in a second volume.

Even accepting Professor Jefferson's present placing of emphasis, the logic of the arrangement of some of the chapters is not easily apparent. For example, the concluding chapters are on air pressure and winds. If air pressure and winds function geographically, they function chiefly in their influence on rainfall, and the explanation of them should precede the explanation of rainfall. If they are not essential for an understanding of rainfall, what place have they in a geography text?

The style of the book might be termed Jeffersonian, for the wit of the author and a keen sense of humor serve to enliven and make interesting even the discussion of the most difficult subjects.

JOHN E. ORCHARD